Radiological Health Data

VOLUME V, NUMBER 10

OCTOBER 1964

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Public Health Service

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data is published by the Public Health Service on a monthly basis. Data are provided to the Division of Radiological Health by other Federal agencies, State health departments, and foreign governments. Pertinent original data and interpretive papers are invited from investigators. Accepted material will be appropriately credited. The reports are reviewed by a Board of Editorial Advisors with representatives from the following Federal agencies:

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RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 10
OCTOBER 1964

TABLE OF CONTENTS

Page

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation 457
1. Radiation Surveillance Network, June 1964, *PHS* 457
2. National Air Sampling Network, Second Quarter 1964, *PHS* 461
3. Canadian Air Monitoring Program, June 1964 464
4. Mexican Air Monitoring Program, June 1964 465
5. Pan American Air Sampling Program, June 1964, *PAHO and PHS* 467
6. Gross Beta Activity in Air, North America, June 1964 467

Fission Product Gamma Activity in Surface Air—80th Meridian and U.S. Locations, May 1964, *William R. Collins, Jr.* 469

SECTION II.—MILK AND FOOD

Milk Surveillance 471
1. Pasteurized Milk Network, June 1964, *PHS* 471
2. Colorado Milk Network, January 1962—June 1964 475
3. Florida Milk Network, 1963 477
4. Indiana Milk Network, June 1964 479
5. New York Milk Network, April 1964 479
6. Pennsylvania Milk Network, April–June 1964 480
7. Canadian Milk Network, June 1964 481

Moving Annual Average Radionuclide Concentrations in Pasteurized Milk July 1963–June 1964, *PHS* 483

Radionuclides in Institutional Diet Samples, January–March 1964, *PHS* 485

SECTION III.—WATER

Strontium–90 and Gross Radioactivity in Surface Waters of the United States, April 1964, *PHS* 493

SECTION IV.—OTHER DATA

Progress in Dental Radiological Health, *James W. Miller* 499

Utah Dental X-Ray Machine Survey, *John W. Wheeler* and *Grant S. Winn* 505

Strontium–90 in Human Vertebrae, 1962–1963, *Joseph Rivera* 511

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 514
1. Lawrence Radiation Laboratory, Calendar Year 1963 514
2. Los Alamos Scientific Laboratory, 1962–1963 518

Reported Nuclear Detonations, September 1964 ... 519

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 6.

1. Radiation Surveillance Network June 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of naturally-occurring radon daughters. The network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are reported, appropriate Federal and State officials are promptly notified.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS

after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the time of collection.[1] The daily concentrations and estimated ages of selected samples are reported by the PHS in a monthly RSN report (*1*).

Table 1 lists the twenty highest gross beta concentrations among the samples observed in June. The June 18 sample from Columbus, Ohio, exhibited the highest activity for the month.

The June 1964 average gross beta concentration in air for each station is given in table 2. The network average for June (1.58 pc/m^3) decreased from the May average (1.94 pc/m^3), which appears to have been the "spring peak". The twenty highest samples in June ranged from 4.85 to 6.62 pc/m^3. In May the twenty highest samples ranged from 5.16 to 8.44 pc/m^3. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

TABLE 1.—GROSS BETA ACTIVITY OF THE TWENTY INDIVIDUAL RSN AIR FILTERS HAVING HIGHEST ACTIVITIES DURING JUNE 1964

Station		Date June	Concentration (pc/m^3)
D. C:	Washington	12	5.50
		13	5.16
Del:	Dover	9	4.72
Ill:	Springfield	4	4.84
Ind:	Indianapolis	12	5.12
		17	4.85
Miss:	Jackson	5	5.03
N. Y:	Buffalo	1	4.99
Ohio:	Cincinnati	12	6.10
		18	5.31
	Columbus	12	5.15
		17	5.46
		18	6.62
	Painesville	13	6.32
Pa:	Harrisburg	29	5.90
R. I:	Providence	20	5.50
Vt:	Barre	3	5.54
Va:	Richmond	17	4.84
W. Va:	Charleston	17	5.25
		18	5.86

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value and cannot be used for estimating date of formation.

TABLE 2.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, JUNE 1964

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity (pc/m³)			Last profile in *RHD*	Average concentration (pc/liter) [b]	Total deposition [b] (nc/m²)
			Maximum	Minimum	Average [a]			
Alabama:	Montgomery	22	3.28	0.15	1.27	Aug 64	310	36.3
Alaska:	Adak	27	3.45	<0.10	0.63	Nov 63	[b]	
	Anchorage	29	1.97	<0.10	0.55	Jul 64	360	7.2
	Attu	30	2.41	<0.10	0.63	Dec 63		
	Fairbanks	28	3.15	<0.10	1.27	Aug 64	470	15.5
	Juneau	13	0.72	<0.10	0.33	Sep 64	310	20.4
	Kodiak	20	0.94	<0.10	0.32	Oct 64		
	Nome	7	2.42	<0.10	1.21	Feb 64		
	Point Barrow	0	0	0	0	Jan 64		
	St. Paul Island	27	1.76	<0.10	0.47	Mar 64		
Ariz:	Phoenix	29	3.19	0.46	2.17	Sep 64		
Ark:	Little Rock	29	3.02	0.39	1.37	Sep 64	420	4.6
Calif:	Berkeley	20	0.92	0.15	0.52	Oct 64	250	4.3
	Los Angeles	21	1.82	0.25	0.73	Feb 64	610	4.8
Canal Zone:	Ancon	11	0.11	<0.10	<0.10	Apr 64		
Colo:	Denver	27	3.66	0.42	1.99	Oct 64	520	3.9
Conn:	Hartford	30	3.51	0.76	1.95	Oct 64	470	24.8
Del:	Dover	20	4.72	0.74	2.31	Aug 64		
D. C:	Washington	26	5.50	0.47	2.83	Aug 64	550	15.9
Fla:	Jacksonville	29	2.86	0.28	1.53	Sep 64	270	35.1
	Miami	30	2.42	0.11	0.86	Oct 64	260	58.6
Ga:	Atlanta	30	2.25	0.20	0.89	Jul 64	280	34.9
Guam:	Agana	23	0.60	<0.10	0.21	Apr 64		
Hawaii:	Honolulu	30	3.92	0.30	0.81	Feb 64		
Idaho:	Boise	29	2.58	0.34	1.41	Dec 63	460	23.6
Ill:	Springfield	28	4.84	0.37	1.90	Mar 64	330	10.0
Ind:	Indianapolis	29	5.12	0.55	2.15	Jul 64	610	49.2
Iowa:	Iowa City	29	4.29	0.95	1.96	Jan 64	230	20.9
Kans:	Topeka	22	2.67	0.16	1.03	Jul 64	240	46.4
Ky:	Frankfort	28	4.61	0.57	1.94	Feb 64	340	16.0
La:	New Orleans	29	2.30	0.23	1.02	Mar 64	220	20.8
Maine:	Augusta	29	4.24	0.46	2.28	Mar 64	670	35.6
	Presque Isle	29	3.76	<0.10	1.73	Nov 63		
Md:	Baltimore	22	4.25	0.67	2.20	Oct 64	410	18.3
	Rockville	12	3.55	0.58	1.38	Mar 64		
Mass:	Lawrence	28	3.91	0.82	2.25	Aug 64	980	23.2
	Winchester	27	3.05	0.48	1.60	Apr 64	830	39.5
Mich:	Lansing	28	4.58	0.83	2.68	Feb 64	610	39.0
Minn:	Minneapolis	30	3.11	0.13	1.56	Mar 64	560	31.3
Miss:	Jackson	28	5.03	0.43	1.69	Apr 64	210	17.6
	Pascagoula	0	0	0	0	Dec 63		
Mo:	Jefferson City	30	3.00	0.13	1.26	Jul 64	260	36.7
Mont:	Helena	29	2.99	0.20	1.28	Nov 64	620	38.8
Nebr:	Lincoln	0	0	0	0	Apr 64		
Nev:	Las Vegas	22	3.71	1.53	2.73	Aug 64		
N. H:	Concord	21	4.28	1.19	2.61	Feb 64	480	18.7
N. J:	Trenton	30	4.07	0.64	2.19	Apr 64		
N. Mex:	Santa Fe	22	4.16	0.67	1.65	Dec 63	1,070	5.7
N. Y:	Albany	21	3.30	0.88	1.92	Jul 64	220	3.8
	Buffalo	12	4.99	0.68	2.63	Nov 63	[b]	
	New York	30	3.91	0.71	2.55	Dec 63		
N. C:	Gastonia	30	3.92	0.46	1.70	Jan 64	300	33.9
N. Dak:	Bismarck	28	4.05	0.25	1.93	Feb 64	610	100.0
Ohio:	Cincinnati	19	6.10	0.55	2.10	Aug 64		
	Columbus	30	6.62	0.52	2.50	Apr 64	500	65.6
	Painesville	29	6.32	1.06	3.08	Oct 64	920	39.1
Okla:	Oklahoma	26	3.30	0.20	0.98	Apr 64	200	4.0
	Ponca City	30	1.39	<0.10	0.64	Oct 64	330	21.7
Ore:	Portland	27	3.45	0.20	1.28	Oct 63	350	16.5
Pa:	Harrisburg	29	5.90	0.51	2.04	Jul 64	560	15.4
P. R:	San Juan	29	1.32	0.30	0.72	Mar 64	200	19.5
R. I:	Providence	26	5.50	0.65	2.58	Jan 64	440	9.8
S. C:	Columbia	28	2.43	0.50	1.29	Dec 63	580	37.7
S. Dak:	Pierre	30	2.80	0.26	1.44	Sep 64	340	18.7
Tenn:	Nashville	28	4.71	0.53	1.93	Jan 64	620	23.8
Tex:	Austin	30	2.43	<0.10	0.85	Aug 64	220	18.7
	El Paso	30	2.67	0.71	1.55	Jan 64		
Utah:	Salt Lake City	30	3.49	0.61	1.67	Aug 63	470	34.0
Vt:	Barre	30	5.54	0.92	3.12	Sep 64	790	22.5
Va:	Richmond	30	4.84	0.52	1.92	Sep 64	330	21.9
Wash:	Seattle	30	1.45	<0.10	0.46	Jul 64	400	32.0
W. Va:	Charleston	29	4.71	0.76	2.64	Dec 63	480	27.5
Wisc:	Madison	30	5.86	0.41	1.98	Sep 64	280	15.9
Wyo:	Cheyenne	30	2.69	0.72	1.64	Aug 64	1,390	17.2
Network summary		1,860	6.62	<0.10	1.58		393	25.6

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Blank spaces indicate precipitation not sampled.

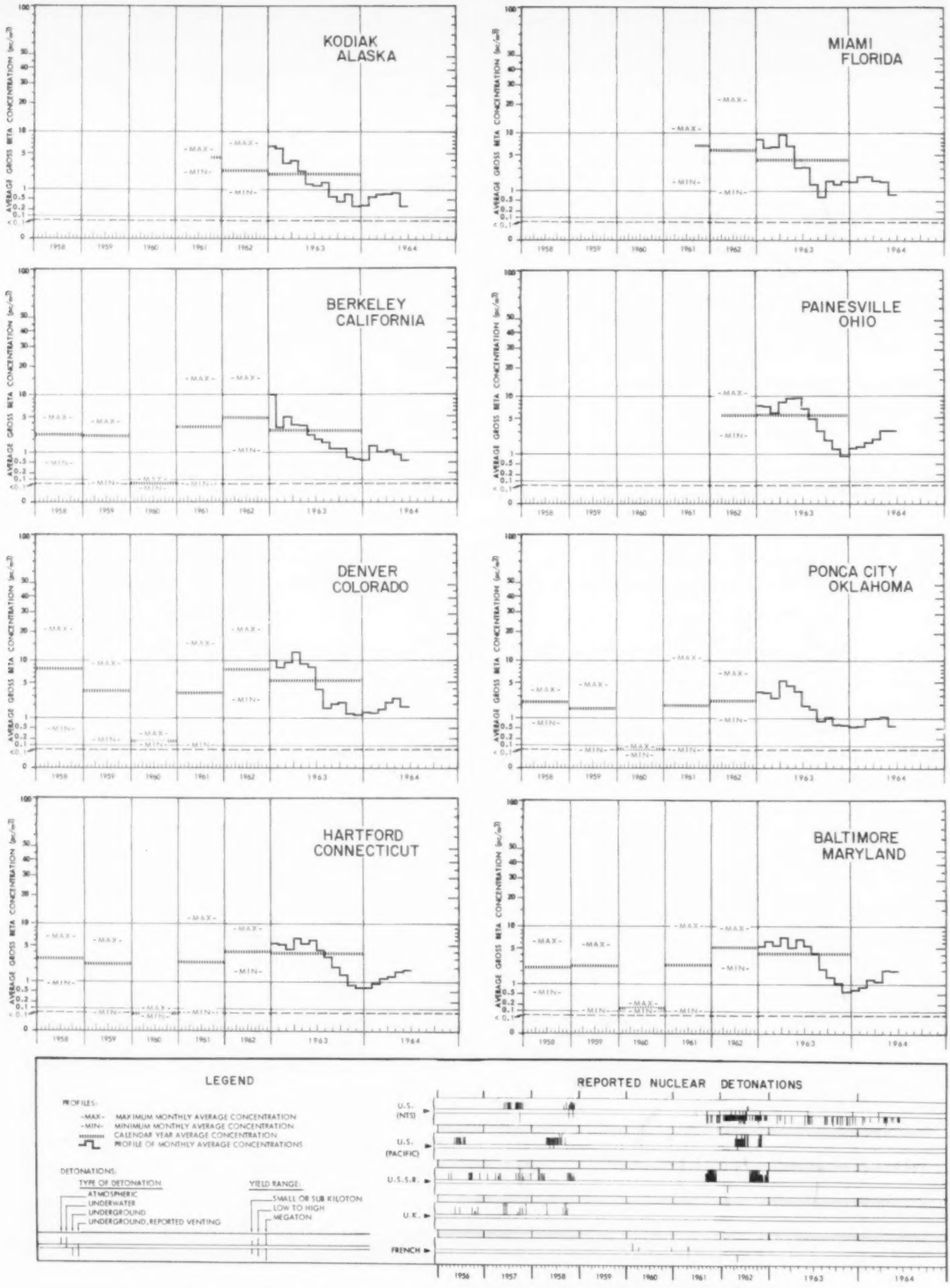

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1958–JUNE 1964

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The June 1964 average concentrations and total depositions are given in table 2.

2. National Air Sampling Network Second Quarter 1964

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in air quality with respect to time, location, population density, climate and other factors.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Second quarter 1964 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the Network laboratory for analysis.

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NASN, SECOND QUARTER, 1964

[Concentrations in pc/m³]

	Station location	Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	2.9	0.8	2.0
	Gadsden	7	3.3	0.8	2.0
	Mobile	6	3.2	1.0	2.0
Alaska:	Anchorage	6	3.8	0.3	1.1
Ariz:	Grand Canyon Pk.[a]	6	5.0	1.8	3.4
	Maricopa Co.[a]	7	8.0	3.3	5.2
	Phoenix	7	5.7	3.0	4.2
	Tucson	7	6.5	1.0	4.0
Ark:	Little Rock	6	3.6	0.3	2.0
	Montgomery Co.[a]	7	5.5	0.5	2.8
	Texarkana	6	2.9	0.6	1.7
Calif:	Bakersfield	5	5.6	1.1	2.6
	Burbank	6	3.6	0.9	2.2
	Humboldt Co.[a]	6	1.4	0.3	0.6
	Los Angeles	6	1.7	0.3	1.2
	Monterey	5	2.4	0.4	1.3
	Oakland	6	3.6	0.4	1.2
	Pasadena	6	3.8	1.1	2.4
	Sacramento	6	4.9	0.6	2.0
	San Diego	6	4.0	0.7	2.2
	San Francisco	6	2.9	0.5	1.3
	Santa Ana	6	3.2	0.7	1.8
	Santa Barbara	7	2.0	0.7	1.4
Colo:	Denver	7	5.8	1.2	3.1
	Montezuma Co.[a]	6	5.7	1.0	2.7
Conn:	Hartford	6	3.5	0.9	2.7
	New Haven	7	4.9	0.6	2.7
Del:	Kent Co.[a]	6	4.4	1.3	3.0
	Wilmington	6	4.5	1.2	3.2
D. C:	Washington	7	5.6	0.2	2.9
Fla:	Florida Keys [a]	5	4.1	0.9	1.8
	Jacksonville	6	4.0	0.9	2.5
	Orlando	6	4.4	1.2	2.4
	Tampa	7	4.5	1.4	2.7
Ga:	Atlanta	6	3.3	0.8	2.0
Hawaii:	Honolulu	7	1.3	0.5	0.9
Idaho:	Boise	6	4.2	0.4	2.1
	Butte Co.[a]	6	5.5	0.7	2.5
Ill:	Chicago	5	3.2	0.1	1.7
	Cicero	6	4.0	2.3	2.7
	Moline	6	2.6	0.9	1.8
	Peoria	6	2.7	1.1	1.8
	Rock Island	5	4.6	2.2	3.4
Ind:	East Chicago	5	2.4	1.5	2.0
	Evansville	7	3.9	0.6	2.0
	Fort Wayne	6	4.1	0.8	2.6
	Gary	3	3.7	2.1	2.9
	Indianapolis	7	3.8	0.8	2.8
	Lafayette	6	2.5	0.8	1.9
	Parke Co.[a]	7	2.9	1.1	2.1
Iowa:	Davenport	7	3.1	1.4	2.3
	Delaware Co.[a]	6	2.3	0.6	1.6
	Des Moines	7	3.6	1.1	2.4
	Dubuque	6	2.3	0.6	1.6
Kans:	Kansas City	5	2.6	1.2	1.9
	Wichita	6	3.0	0.4	2.2
Ky:	Ashland	6	6.5	1.4	3.0
	Covington	6	5.7	1.2	3.0
	Louisville	6	3.0	0.5	2.0
La:	Baton Rouge	6	2.8	1.1	2.0
	Lake Charles	6	3.4	0.6	1.8
	New Orleans	6	3.8	0.8	2.3
Maine:	Acadia Nat'l. Pk.[a]	6	2.4	1.7	2.0
	Portland	6	3.5	1.0	2.1
Md:	Baltimore	6	4.6	0.3	3.0
	Calvert Co.[a]	6	5.1	0.4	3.4
Mass:	Boston	7	3.5	0.6	2.3
	Springfield	5	3.8	0.4	2.0
Mich:	Detroit	7	4.3	0.6	2.5
	Wyandotte	5	4.7	1.8	3.3
Minn:	Duluth	6	2.7	0.5	1.4
	Minneapolis	6	2.7	0.6	1.5
	Moorhead	6	3.2	1.1	2.2
	St. Paul	6	2.6	0.8	1.5
Miss:	Jackson	6	3.3	0.7	2.1
	Jackson County [a]	5	2.5	1.5	1.9
Mo:	Kansas City	5	4.1	0.5	2.4
	Shannon Co.[a]	6	3.6	1.8	2.7
	St. Louis	6	3.1	0.7	2.0
Mont:	Glacier Nat'l. Pk.[a]	3	2.5	0.9	1.6
	Helena	6	4.6	0.2	2.1
Nebr:	Omaha	6	4.3	0.4	2.7
	Thomas Co.[a]	6	6.4	1.2	2.6
Nev:	Las Vegas	6	4.9	2.5	3.3
	White Pine Co.[a]	5	4.6	0.8	2.6
N. H:	Concord	6	3.3	0.8	2.[illegible]
	Coos Co.[a]	7	3.4	0.2	2.[illegible]
N. J:	Camden	6	4.6	0.4	3.[illegible]
	Jutland	6	4.2	0.2	2.[illegible]
	Marlton	3	5.8	2.9	4.[illegible]
	Newark	7	3.8	0.3	2.[illegible]
	New Brunswick	6	3.5	0.3	2.[illegible]
	Pemberton	6	4.4	0.3	2.[illegible]
	Perth Amboy	6	5.2	0.3	2.[illegible]
	Princeton	5	3.8	0.4	2.[illegible]
	Trenton	4	3.3	0.4	2.[illegible]
	Glassboro	6	4.5	0.3	3.[illegible]
N. M:	Albuquerque	6	5.8	2.6	3.[illegible]
	Rio Arriba Co.[a]	6	4.8	2.0	3.[illegible]
N. Y:	Cape Vincent [a]	6	3.2	0.2	2.[illegible]
	New York	6	5.7	0.5	3.[illegible]
N. C:	Cape Hatteras	6	6.4	0.5	2.[illegible]
	Charlotte	7	4.1	1.7	2.[illegible]
	Fayetteville	7	4.2	1.7	3.[illegible]
	Winston-Salem	6	4.4	0.6	3.[illegible]
N. Dak:	Bismarck	6	6.1	1.1	2.[illegible]
	Fargo	6	3.3	0.7	1.[illegible]
	Ward Co.[a]	7	5.3	0.4	2.[illegible]
Ohio:	Akron	7	3.7	1.3	2.[illegible]
	Cincinnati	6	6.0	1.2	3.[illegible]
	Cleveland	6	3.2	0.8	2.[illegible]
	Columbus	6	6.5	1.5	2.[illegible]
	Dayton	6	6.8	1.6	3.[illegible]
	Lorain	6	3.1	0.4	2.[illegible]
	Steubenville	6	3.0	1.3	2.[illegible]
	Toledo	7	6.5	0.6	3.[illegible]
	Youngstown	6	3.6	0.9	2.[illegible]
Okla:	Cherokee Co.[a]	7	5.0	0.4	2.[illegible]
	Oklahoma City	6	4.6	0.5	2.[illegible]
	Tulsa	6	3.9	0.4	2.[illegible]
Ore:	Portland	6	1.3	0.1	0.[illegible]
	Curry County [a]	7	3.5	0.7	1.[illegible]
Pa:	Clarion Co.[a]	5	3.1	1.1	1.[illegible]
	Embreeville	6	3.4	0.2	2.[illegible]
	Lancaster	7	4.5	0.3	2.[illegible]
	Philadelphia	6	4.4	0.3	3.[illegible]
	Pittsburgh	6	3.5	0.6	2.[illegible]
	West Chester	2	1.7	0.2	1.[illegible]
P. R:	Guayanilla	7	2.6	0.9	1.[illegible]
	Ponce	7	2.8	1.2	1.[illegible]
	San Juan	6	2.7	0.8	1.[illegible]
R. I:	Providence	6	4.0	1.2	2.[illegible]
	Washington Co.[a]	7	5.1	1.7	3.[illegible]
S. C:	Columbia	4	4.6	1.6	2.[illegible]
	Richland Co.[a]	5	3.9	1.5	2.[illegible]
S. Dak:	Black Hills	7	4.9	0.5	2.[illegible]
	Sioux Falls [a]	6	2.5	0.5	1.[illegible]
Tenn:	Chattanooga	7	5.1	1.0	2.[illegible]
	Memphis	6	5.7	1.2	2.[illegible]
	Nashville	6	3.3	1.1	2.[illegible]
Tex:	Aransas Co.[a]	7	3.1	0.6	1.[illegible]
	Dallas	6	3.2	0.5	2.[illegible]
	El Paso	6	6.3	1.4	3.[illegible]
	Houston	6	4.5	0.5	2.[illegible]
	Laredo	6	5.2	0.3	1.[illegible]
	San Antonio	6	5.1	0.5	2.[illegible]
	Texarkana	6	2.7	0.5	1.[illegible]
	Waco	6	3.7	1.2	2.[illegible]
Utah:	Ogden	6	3.2	0.9	2.[illegible]
	Salt Lake City	6	5.2	0.8	3.[illegible]
Vt:	Burlington	7	4.2	0.1	2.[illegible]
	Orange Co.[a]	6	3.1	0.1	2.[illegible]
Va:	Danville	6	6.1	0.5	3.[illegible]
	Norfolk	7	5.6	0.7	3.[illegible]
	Shenandoah Pk.[a]	6	4.2	0.5	2.[illegible]
Wash:	Seattle	6	1.6	0.2	0.[illegible]
	Tacoma	6	1.7	0.1	0.[illegible]
W. Va:	Charleston	7	5.2	1.7	2.[illegible]
	Huntington	5	6.8	2.5	3.[illegible]
	Parkersburg	6	6.3	1.1	2.[illegible]
	Weirton	7	4.2	1.4	2.[illegible]
Wis:	Door Co.	7	2.9	0.8	2.[illegible]
	Eau Claire [a]	7	3.1	0.6	2.[illegible]
	Milwaukee	6	3.1	1.5	2.[illegible]
	Racine	6	2.4	0.5	1.[illegible]
	Superior	6	2.2	0.4	1.[illegible]
Wyo:	Cheyenne	6	5.4	1.9	3.[illegible]
	Yellowstone Pk.[a]	6	3.0	0.4	1.[illegible]
Network summary		1,015	8.0	0.1	2.37

[a] Nonurban stations.

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1964

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for April and May 1964 are presented in table 4.

Effective with the June 1964 samples, the responsibility for the conduct of the precipitation program was assumed by the National Center for Atmospheric Research, Boulder, Colorado. No further publication of radioactivity in precipitation data from the NASN is anticipated.

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, NASN, APRIL AND MAY 1964

Station		April		May	
		pc/liter	nc/m²	pc/liter	nc/m²
Ala:	Montgomery	285	85	555	22
Fla:	Tampa			350	26
Ill:	Chicago (O'Hare)	1245	141		
	Chicago (Midway)	2,250	98		
La:	Lake Charles			465	23
Maine:	Caribou			810	52
Mass:	Nantucket	510	63		
Mich:	Sault Ste. Marie	750	52	970	57
Minn:	St. Cloud	565	45	620	56
Mo:	Columbia	1,075	137	870	81
Mont:	Glasgow			305	12
Nebr:	Grand Island	410	41		
N. Y:	Albany	1,230	62		
N. C:	Cape Hatteras	540	53	570	32
Ohio:	Cincinnati (Airport)	465	75		
	Cincinnati (Gest St.)	575	67		
Pa:	Philadelphia	650	85		
S. C:	Charleston	340	22	480	61
	Greenville	375	111	555	22
Tenn:	Nashville	620	70	450	46
Tex:	Brownsville			245	15
Va:	Sterling	635	53		
Wash:	Tatoosh	475	24		

3. Canadian Air Monitoring Program [2] June 1964

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of the National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window gas-flow, Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for June 1964 are given in table 5 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After

[2] Data from *Radiation Protection Programs 7:* 11–24, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (July 1964).

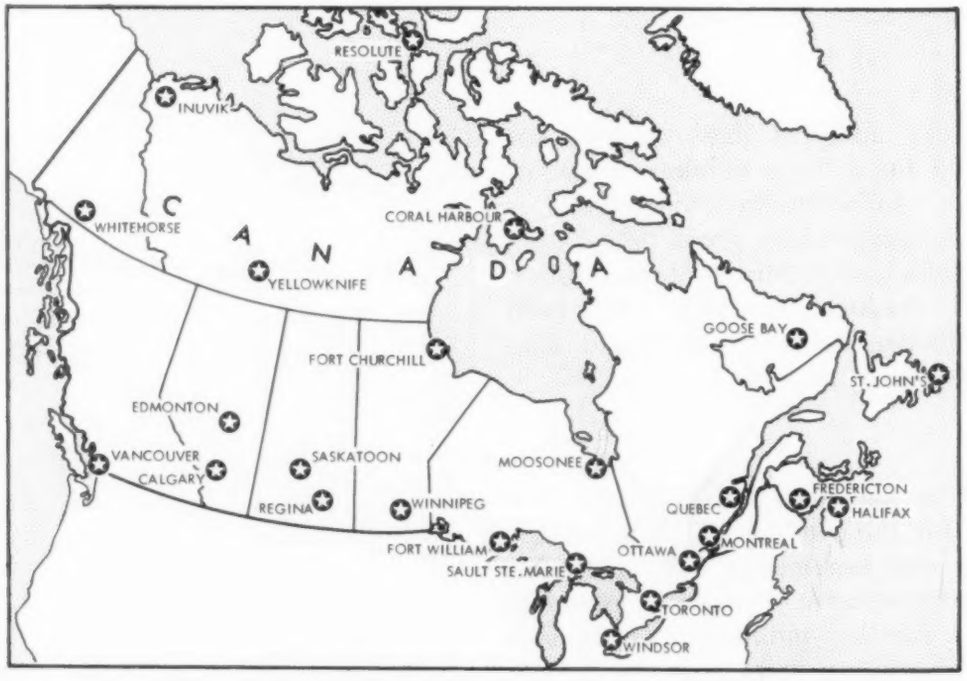

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS

TABLE 5.—GROSS BETA ACTIVITY IN SURFACE AIR AND PRECIPITATION, CANADA, JUNE 1964

Station	Air surveillance				Precipitation data	
	Number of samples	Gross beta activity (pc/m³)			Average concentration (pc/liter)	Total deposition (nc/m²)
		Maximum	Minimum	Average		
Calgary	29	4.1	0.1	1.6	612	53.6
Coral Harbour	29	1.7	0.1	0.4	962	29.8
Edmonton	29	3.5	0.6	1.9	1,772	46.8
Ft. Churchill	27	1.9	0.1	0.8	868	35.0
Ft. William	30	6.7	0.2	1.6	944	133.4
Fredericton	30	2.5	0.1	1.2	1,077	60.4
Goose Bay	28	5.0	0.1	1.3	598	89.1
Halifax	28	2.8	0.2	1.3	829	49.4
Inuvik	30	3.0	0.2	1.2	872	33.2
Montreal	29	3.8	0.7	2.3	1,214	37.9
Moosonee	30	3.6	0.3	1.5	666	73.6
Ottawa	30	3.2	0.3	2.0	943	29.7
Quebec	30	3.0	0.5	1.9	690	82.0
Regina	28	7.6	0.2	2.4	936	84.1
Resolute	30	1.3	0.1	0.4	1,093	21.9
St. John's, Nfld	28	2.5	0.1	0.9	656	51.8
Saskatoon	28	4.3	0.6	2.5	2,768	46.4
Sault Ste. Marie	30	3.5	0.1	1.6	819	55.1
Toronto	28	4.3	0.5	1.8	541	17.6
Vancouver	30	2.1	0.2	0.6	742	41.6
Whitehorse	30	2.2	0.2	0.9	673	20.8
Windsor	26	3.6	0.5	2.1	868	84.8
Winnipeg	28	3.3	0.2	1.7	681	81.0
Yellowknife	29	2.9	0.3	1.5	3,253	16.5
Network summary		3.4	0.3	1.5	1,045	53.1

transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for June 1964 samples are given in table 5. Radionuclide analyses are reported quarterly in *RHD*.

4. Mexican Air Monitoring Program June 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the *Comisión Nacional de Energía Nuclear* (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

In 1961 the CNEN appointed its Division of Radiological Protection (DRP) to establish a new Radiation Surveillance network. This network consists of 17 stations (see figure 5), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the DRP operate the station at Mexico City while the other four stations are

manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Dersérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24 hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collections is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum and average fission product beta concentrations in surface air during June 1964, are presented in table 6. The data are also represented in the beta activity isogram map of North America, figure 6.

TABLE 6.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, JUNE 1964

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco	9	1.0	0.1	0.4
Ciudad Juárez	25	1.8	0.4	1.1
Chihuahua	20	1.9	0.4	1.3
Ensenada	8	1.6	0.2	0.9
Guadalajara	11	2.0	0.3	1.1
Guaymas	9	3.2	0.6	1.3
La Paz	22	2.2	0.1	1.1
Matamoros	8	1.3	0.2	0.8
Mazatlán	14	2.9	0.9	1.7
Mérida	17	2.0	0.2	0.9
México, D.F.	22	1.4	0.1	0.7
Nuevo Laredo	14	1.3	0.2	0.9
San Luis Potosí	18	2.1	0.2	1.2
Tampico	18	1.6	0.1	0.8
Torreón	18	3.5	0.6	1.9
Tuxtla Gutiérrez [a]				
Veracruz	20	2.3	0.1	1.1

[a] Temporarily shut down.

FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

5. Pan American Air Sampling Program June 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by four countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The four air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; and in Santiago, Chile, by the Occupational Health Service. The Kingston station began operation in March 1964 and the other three were started near the end of 1962.

The June 1964 air monitoring results from the four participating countries are given in table 7. The Caracas and Jamaica stations, included in figure 6 with the June averages adjusted by the RSN intercalibration factor,[3] were used in positioning the beta concentration isograms.

[3] The RSN factor is 1.28.

TABLE 7.—GROSS BETA ACTIVITY IN AIR, JUNE 1964

[Concentrations in pc/m³]

Sampling stations	No. of samples	Maximum	Minimum	Average [a]
Kingston, Jamaica	17	0.92	0.22	0.43
Caracas, Venezuela	21	0.38	<0.10	0.19
Lima, Peru	19	0.31	<0.10	0.11
Santiago, Chile	19	0.19	<0.10	0.17

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross Beta Activity in Air, North America June 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America. The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*13*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*14*). The new intercalibration factors reflect some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963.

Figure 6 shows the June 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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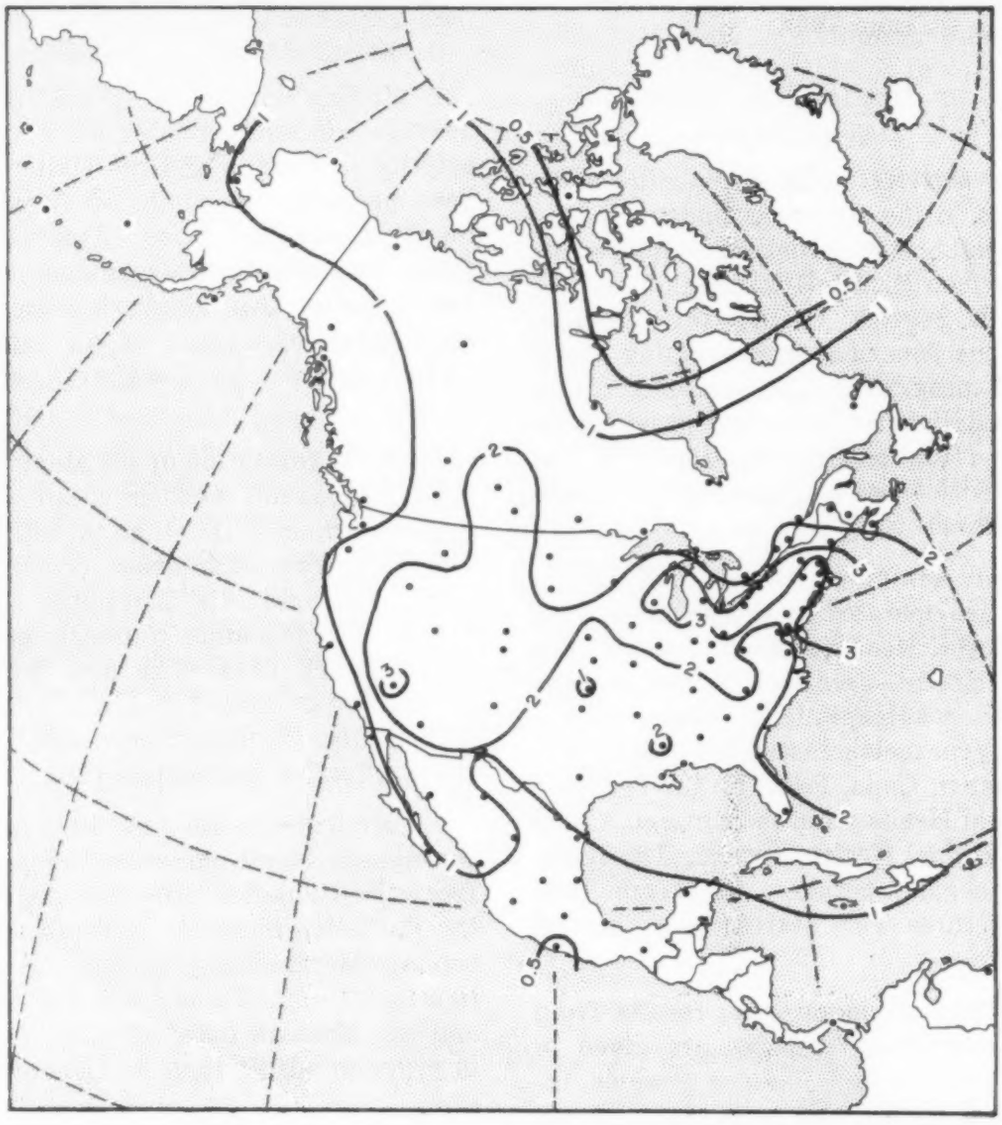

FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR, NORTH AMERICA, JUNE 1964

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FISSION PRODUCT GAMMA ACTIVITY IN SURFACE AIR— 80TH MERIDIAN AND U.S. LOCATIONS, MAY 1964

William R. Collins, Jr.[1]

Fourteen air sampling stations near the 80th Meridian (West) from Thule, Greenland, to Punta Arenas, Chile, make up the Health and Safety Laboratory (HASL) 80th Meridian Network (figure 1). An additional station at Mauna Loa, Hawaii, is included for comparing data with that from Chacaltaya, Bolivia; both are at a high elevation and their respective latitudes North and South are nearly equal. Data are also reported for the six additional stations in the United States, as described in the August 1964 *RHD* (*1*).

Air particulates are sampled on 8-inch-diameter polystyrene filters drawing air through the filters continuously at the rate of about 1400 cubic meters per day. Filters are changed at noon on the 1st, 8th, 15th, and 22nd of each month and forwarded to HASL for analysis. A total gamma count is made approximately

[1] Mr. Collins is a chemist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission.

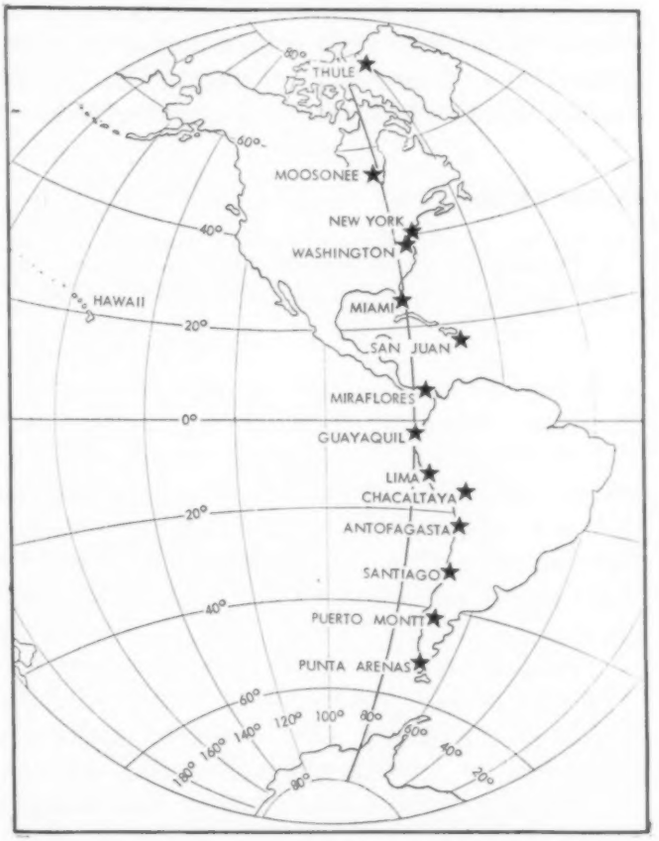

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS (6 NEW U. S. STATIONS NOT SHOWN)

TABLE 1.—GAMMA ACTIVITY IN SURFACE AIR, 80TH MERIDIAN NETWORK AND U.S. STATIONS, MAY 1964

[Activity in gamma photons/min/m³]

Station latitude, elevation	May sampling periods				May average
	1–7	8–15	16–21	22–31	
80TH MERIDIAN NETWORK:					
Thule, Greenland 77° N, 259 m	0.923	1.02	1.42	0.656	0.972
Moosonee, Canada 51° N, 10 m	1.64	0.647	0.938	0.706	0.950
New York, N. Y. 41° N, 38 m	2.14	1.83	1.65	1.42	1.76
Washington, D. C. 39° N, 82 m	1.51	1.76	1.49	1.62	1.60
Miami, Fla. 26° N, 4 m	0.724	1.58	1.09	0.889	1.05
Mauna Loa, Hawaii 19° N, 3394 m	1.32	1.99	0.770	0.638	1.11
San Juan, P. R. 18° N, 10 m	0.856	0.950	0.939	0.604	0.823
Miraflores, Canal Zone 9° N, 10 m	0.269	0.717	0.738	0.108	0.419
Guayaquil, Ecuador 0°–08′ S, 7 m	0.0235	0.0278	0.0370	0.0275	0.0289
Lima, Peru 12° S, 30 m	0.0464	0.0407	0.0287	0.0408	0.0401
Chacaltaya, Bolivia 17° S, 5220 m	0.0602	0.0586	0.0493	0.0702	0.0603
Antofagasta, Chile 24° S, 519 m	0.0459	0.0526	0.0435	0.0407	0.0452
Santiago, Chile 33° S, 5 m	0.0541	0.0443	0.0530	0.0344	0.0458
Puerto Montt, Chile 41° S, 5 m	0.0191	0.0430	0.0554	0.0405	0.0396
Punta Arenas, Chile 53° S, 3 m	0.0505	0.0504	0.0408	0.0411	0.0454
ADDED U.S. STATIONS:					
Westwood, N. J. 41°00′ N, 38 m	1.56	1.29	1.29	1.37	1.38
Chattanooga, Tenn. 35°03′ N, 206 m	1.71	1.49	1.98	1.48	1.66
Appleton, Wisc. 44°15′ N, 229 m	1.54	1.18	1.36	1.26	1.34
Midwest City, Okla. 35°25′ N, 364 m	1.91	1.95	1.84	1.46	1.79
Palo Alto, Calif. 47°36′ N, 3 m	0.660	1.11	1.07	1.03	0.968
Seattle, Wash. 37°30′ N, 19 m	0.913	1.00	1.14	1.24	1.07

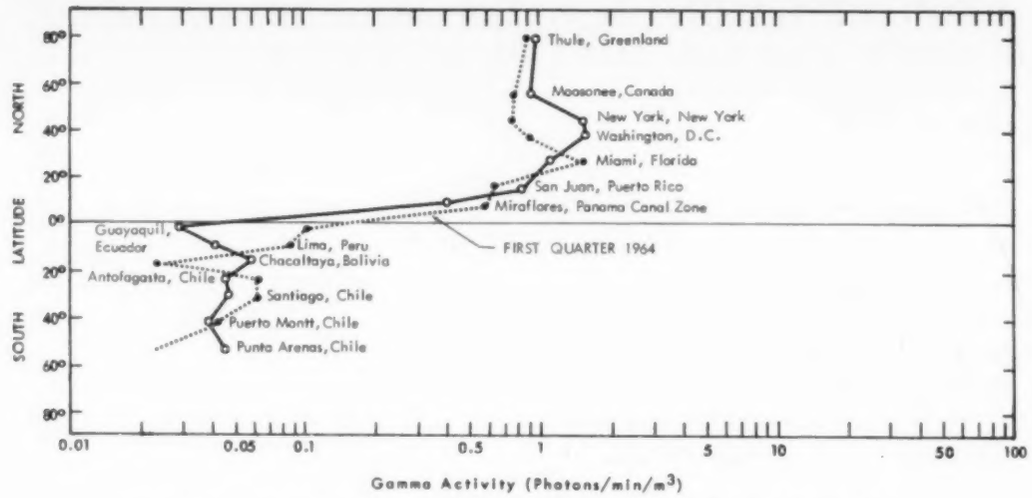

FIGURE 2.—PROFILES OF SURFACE AIR GAMMA ACTIVITY, FIRST QUARTER AND MAY 1964

two weeks after the midpoint of the sampling period, using an 8 x 4-inch sodium iodide (thallium-activated) crystal.

The results of total gamma activity determinations in weekly ground level air filter samples taken at all sampling locations during May 1964 are listed in table 1 together with average monthly activity concentrations calculated for each site. The average monthly activities are also plotted in figure 2 as activity—latitude profiles.

The data show that surface activities at the 80th Meridian sites in the Northern Hemisphere[2] ranged from 0.11 to 2.1 γ/min/m^3 (photons per minute per cubic meter), with an average of 1.1 γ/mm/m^3. In the Southern Hemisphere the range was from 0.019 to 0.070 γ/min/m^3, with an average of 0.044 γ/min/m^3. In comparison to previous data, the May 1964 averages represent an increase with respect to the previous month of about 10 percent in the Northern Hemisphere and a decrease of about 10 percent in the Southern Hemisphere. With respect to the May 1963 values, decreases of 85 percent and 50 percent occurred in the Northern and Southern Hemispheres, respectively.

[2] Does not include six additional U.S. stations.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, June 1964

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling Procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after monthly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analyses.

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. Table 1 gives the 95 percent confidence limits between which the true concentrations of the selected radionuclides might be expected in the individual analyses. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for June 1964 (May 31–June 23, 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963, when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modification to the isograms are made according to available information on milksheds.

In table 3, the distribution of the network's stations with respect to radionuclide concentrations in milk, has been developed from the averages shown in table 2.

The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. The method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of the strontium–90 concentration was given for each station. A tabulation of the network monthly maximum, minimum, and average radionuclide concentration in milk was given for March 1960–March 1964 in the July 1964 issue of *RHD* (*2*).

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

[2] The conversion factor is 1.18×10^{-3} g K/pc K^{40}.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	Second quarter	Avg. for month	
Ala:	Montgomery	1.15	1.16	1.5	1.6	<5	<5	26	23	90	80	Oct
Alaska:	Palmer	1.22	1.18	1.4	1.4	5	5	25	28	150	140	July
Ariz:	Phoenix	1.17	1.17	1.5	1.5	<5	<5	6	5	30	20	Sept
Ark:	Little Rock	1.15	1.15	1.5	1.5	<5	<5	58	49	160	120	July
Calif:	Sacramento	1.24	1.25	1.5	1.5	<5	5	9	8	50	55	Aug
	San Francisco	1.22	1.23	1.4	1.4	<5	<5	12	8	55	50	Oct
Canal Zone:	Cristobal	1.09	1.10	1.5	1.5	<5	<5	6	6	55	50	July
Colo:	Denver	1.22	1.20	1.5	1.5	<5	<5	22	26	90	100	Aug
Conn:	Hartford	1.14	1.14	1.5	1.5	<5	<5	23	23	160	155	Aug
Del:	Wilmington	1.20	1.19	1.5	1.4	<5	<5	30	28	145	130	Sept
D. C:	Washington	1.12	1.14	1.6	1.6	<5	<5	23	24	100	85	Oct
Fla:	Tampa	1.13	1.13	1.5	1.4	<5	<5	15	14	260	270	Sept
Ga:	Atlanta	1.15	1.14	1.5	1.5	<5	<5	36	30	165	130	Oct
Hawaii:	Honolulu	1.16	1.20	1.6	1.5	<5	<5	11	11	85	90	July
Idaho:	Idaho Falls	1.21	1.24	1.4	1.5	10	<5	34	33	205	195	Sept
Ill:	Chicago	1.16	1.13	1.5	1.5	<5	<5	19	23	130	115	Oct
Ind:	Indianapolis	1.20	1.18	1.5	1.5	<5	<5	25	25	110	110	Aug
Iowa:	Des Moines	1.22	1.20	1.4	1.4	5	5	30	28	100	90	Sept
Kans:	Wichita	1.19	1.18	1.4	1.4	5	5	25	30	80	75	July
Ky:	Louisville	1.13	1.13	1.5	1.6	<5	<5	37	36	100	85	Sept
La:	New Orleans	1.18	1.17	1.5	1.5	<5	<5	59	53	180	140	July
Maine:	Portland	1.18	1.17	1.5	1.5	<5	<5	33	35	210	200	Sept
Md:	Baltimore	1.13	1.14	1.5	1.4	<5	<5	28	31	125	105	Sept
Mass:	Boston	1.18	1.16	1.6	1.5	<5	<5	38	43	245	240	Oct
Mich:	Detroit	1.17	1.16	1.5	1.5	<5	<5	21	23	120	105	Aug
	Grand Rapids	1.22	1.19	1.5	1.4	<5	<5	23	26	135	120	Sept
Minn:	Minneapolis	1.22	1.19	1.5	1.5	10	<5	37	42	160	155	Oct
Miss:	Jackson	1.22	1.20	1.5	1.5	<5	<5	53	44	125	100	Aug
Mo:	Kansas City	1.19	1.20	1.4	1.4	10	5	32	30	100	90	Aug
	St. Louis	1.21	1.22	1.4	1.4	10	10	28	28	95	100	July
Mont:	Helena	1.19	1.20	1.5	1.5	5	<5	32	32	195	155	July
Nebr:	Omaha	1.21	1.22	1.5	1.5	5	5	30	31	105	85	Sept
Nev:	Las Vegas	1.20	1.24	1.5	1.5	<5	<5	10	10	90	95	Oct
N. H:	Manchester	1.19	1.18	1.5	1.5	<5	<5	33	36	250	235	Sept
N. J:	Trenton	1.16	1.13	1.5	1.5	<5	<5	23	25	135	125	Aug
N. Mex:	Albuquerque	1.19	1.16	1.5	1.5	5	<5	14	14	70	60	July
N. Y:	Buffalo	1.15	1.12	1.5	1.5	<5	<5	24	28	160	150	Aug
	New York	1.14	1.13	1.5	1.5	<5	<5	30	36	180	170	Oct
	Syracuse	1.16	1.17	1.6	1.5	<5	<5	23	23	160	145	July
N. C:	Charlotte	1.16	1.16	1.5	1.5	<5	<5	43	47	140	135	July
N. Dak:	Minot	1.20	1.20	1.5	1.5	15	10	72	76	175	180	Sept
Ohio:	Cincinnati	1.18	1.16	1.5	1.4	<5	<5	28	26	105	100	Aug
	Cleveland	1.18	1.19	1.5	1.5	<5	<5	25	31	135	140	July
Okla:	Oklahoma City	1.13	1.12	1.6	1.5	<5	<5	27	26	75	75	Oct
Ore:	Portland	1.26	1.27	1.4	1.4	10	10	40	42	190	220	Aug
Pa:	Philadelphia	1.17	1.16	1.5	1.4	<5	<5	25	26	140	120	July
	Pittsburgh	1.18	1.18	1.5	1.5	<5	<5	34	40	175	175	July
P. R:	San Juan	1.11	1.13	1.5	1.5	<5	<5	15	14	90	75	July
R. I:	Providence	1.17	1.16	1.5	1.5	<5	<5	27	30	180	180	Sept
S. C:	Charleston	1.16	1.16	1.5	1.4	<5	<5	35	34	145	120	Aug
S. Dak:	Rapid City	1.14	1.18	1.5	1.5	10	10	48	58	155	170	Oct
Tenn:	Chattanooga	1.17	1.18	1.4	1.4	<5	<5	51	46	145	125	Oct
	Memphis	1.16	1.17	1.5	1.6	<5	<5	42	40	85	70	Sept
Tex:	Austin	1.11	1.12	1.6	1.6	<5	<5	10	10	45	50	Oct
	Dallas	1.12	1.12	1.5	1.5	<5	<5	22	21	70	65	Aug
Utah:	Salt Lake City	1.24	1.21	1.5	1.5	10	5	30	29	195	170	July
Vt:	Burlington	1.18	1.16	1.5	1.5	<5	<5	30	34	190	170	Aug
Va:	Norfolk	1.13	1.16	1.5	1.5	<5	<5	28	28	110	105	Aug
Wash:	Seattle	1.21	1.20	1.5	1.5	10	10	36	40	190	265	Oct
	Spokane	1.27	1.27	1.5	1.5	10	10	29	30	155	150	Aug
W. Va:	Charleston	1.13	1.16	1.5	1.6	<5	<5	34	34	95	80	Oct
Wis:	Milwaukee	1.23	1.22	1.6	1.6	<5	<5	21	21	145	135	Sept
Wyo:	Laramie	1.22	1.18	1.4	1.4	15	20	25	29	120	130	Sept
Network average		1.18	1.17	1.5	1.5	<5	<5	28.9	29.5	133	126	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

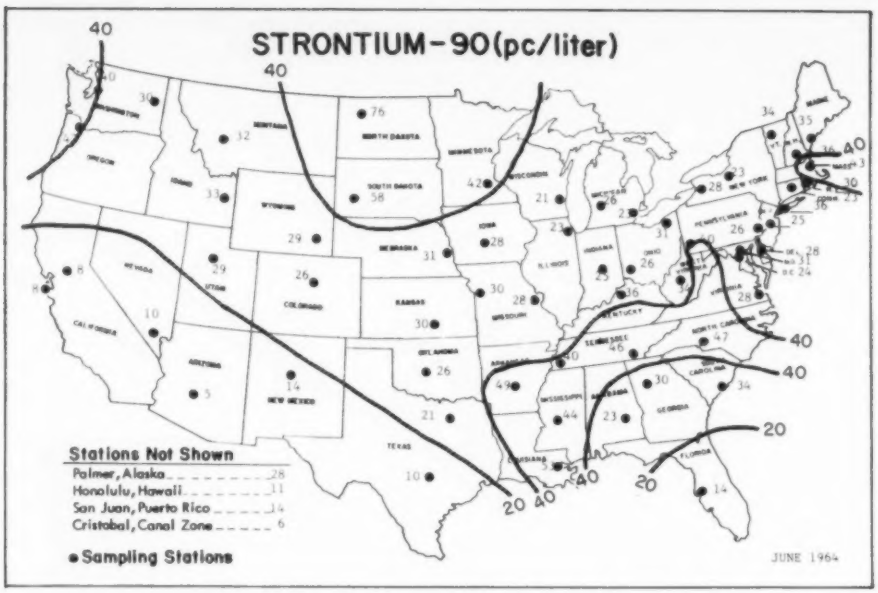

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, JUNE 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations	(pc/liter)	Number of stations
<5	49	<1-9	4	<10	63	<5-45	1	<10	63
5	7	10-19	6			50-95	19		
10	6	20-29	23			100-145	24		
20	1	30-39	17			150-195	13		
		40-49	10			200-245	4		
		50-59	2			250-295	2		
		60-69							
		70-79	1						

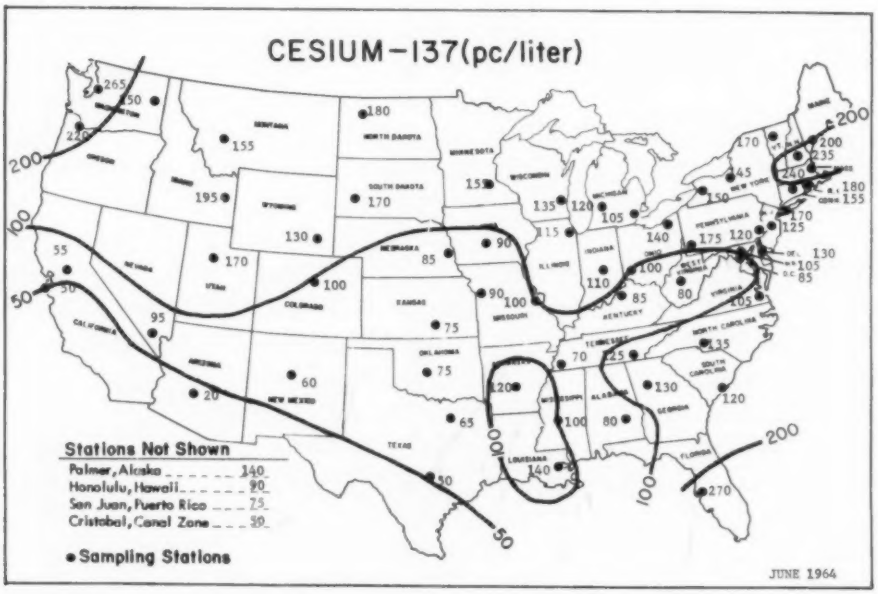

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, JUNE 1964

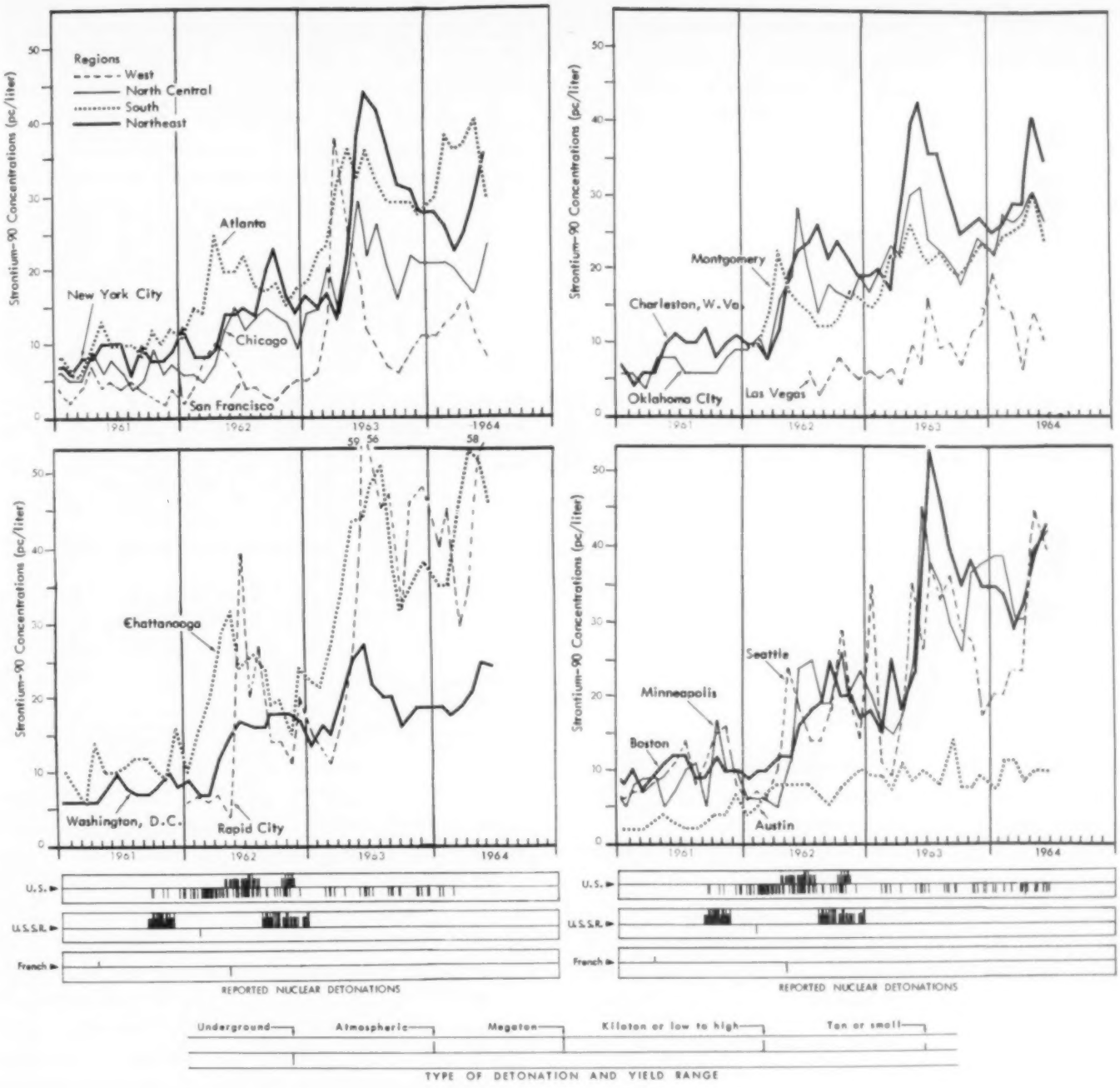

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961–JUNE 1964

2. Colorado Milk Network January 1962-June 1964

Occupational and Radiological Health Division
Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. The Denver Health Department collects weekly pasteurized milk composited samples from all major producers in the Denver area.

The State is divided into three major milk producing areas: west, northeast, and southeast. Routine sampling of raw milk began in August 1962. Raw milk shipped into Colorado from eastern Utah was also sampled. The four source areas are shown in figure 4. Sampling in the west and southeast was discontinued in

TABLE 4.—RADIONUCLIDES IN COLORADO MILK, JANUARY 1962–JUNE 1964 [a]

[Concentrations in pc/liter]

DATE		RAW MILK												PASTEURIZED MILK		
		Northeast			Southeast			West			Eastern Utah			Denver		
		K^{40}	I^{131}	Cs^{137}	K^{40}	I^{131}	Cs^{137}	K^{40}	I^{131}	Cs^{137}	K^{40}	I^{131}	Cs^{137}	K^{40}	I^{131}	Cs^{137}
1962	Jan	1.50	<20	28	[b]			1.61	<20	<20						
	Feb													1.83	<20	40
	Mar													1.63	<20	27
	Apr													1.64	<20	21
	May													1.60	<20	28
	Jun													1.31	<20	72
	Jul															
	Aug							1.58	93	72	1.56	290	117	1.58	77	70
	Sep	1.70	95	84	1.64	<20	22	1.78	52	70	1.66	30	71	1.62	35	65
	Oct	1.50	77	41	1.55	<20	45	1.50	64	67	1.60	34	143	1.62	27	70
	Nov	1.53	66	48	1.45	41	60	1.50	26	48	1.40	<20	48	1.60	<20	54
	Dec	1.60	<20	89	1.58	<20	49	1.48	22	44	1.60	<20	80	1.52	<20	55
1963	Jan				1.50	<20	60	1.50	<20	36	1.40	<20	100	1.53	<20	64
	Feb	1.46	<20	62	1.56	<20	58	1.50	<20	30	1.50	<20	73	1.50	<20	64
	Mar	1.61	<20	90	1.52	<20	62	1.40	<20	<20	1.60	<20	150	1.52	<20	68
	Apr	1.44	<20	45	1.44	<20	55	1.42	<20	34	1.60	<20	167	1.41	<20	57
	May	1.52	<20	69	1.52	<20	53	1.51	<20	46	1.50	<20	122	1.47	<20	70
	Jun	1.41	<20	129	1.39	<20	120	1.38	<20	67	1.30	<20	122	1.51	<20	112
	Jul	1.40	<20	135	1.57	<20	90	1.50	<20	141	1.50	<20	326	1.50	<20	134
	Aug	1.41	<20	130	1.55		100	1.40	<20	109				1.58	<20	116
	Sep															
	Oct	1.53	<20	79							1.58	<20	239	1.40	<20	98
	Nov	1.58	<20	107										1.50	<20	135
	Dec															
1964	Jan	1.29	<20	95							1.37	<20	133	1.53	<20	94
	Feb	1.16	<20	100							1.09	<20	211	1.21	<20	97
	Mar	1.40	<20	104							1.53	<20	236	1.22	<20	100
	Apr	1.32	<20	84										1.64	<20	108
	May	1.28	<20	70							1.34	<20	186	1.33	<20	94
	Jun	1.39	<20	96							1.57	<20	226	1.40	<20	125

[a] Barium-140 monthly averages were <20 pc/liter.
[b] Blanks indicate no analysis.

September 1963. The frequency of sampling varies from one to seventeen times per month in each active sampling area.

Samples are analyzed with the Division's low level counting facilities. The shield is an eight-foot cube having five-inch steel walls lined with one-eighth inch of lead on the inside. A two-quart milk sample in a stainless steel container is analyzed with a 3- x 5-inch thallium-activated

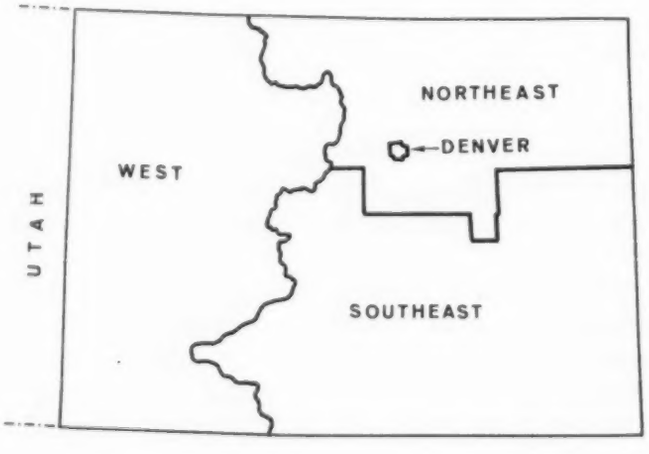

FIGURE 4.—COLORADO MILK SAMPLING AREAS

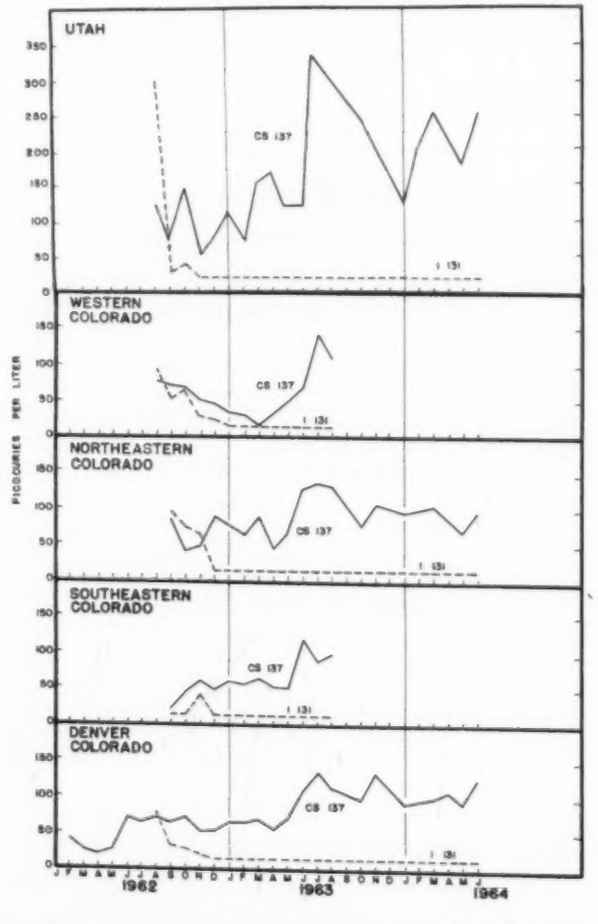

FIGURE 5.—RADIONUCLIDES IN COLORADO MILK

odium iodide crystal and a 512-channel pulse eight analyzer for forty minutes. The system s calibrated for routine calculation by the natrix method for the radionuclides iodine–31, barium–140, cesium–137, and potassium–0. The minimum detectable amount for the irst three radionuclides at the 95 percent confidence level (± two standard deviations) is 0 pc/liter.

Table 4 gives the radionuclide concentration n milk samples collected from January 1962 hrough June 1964. These data are presented graphically in figure 5.

3. Florida Milk Network, 1963

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90 and cesium–137 in addition to iodine–131. Raw milk samples are received from the six areas shown in figure 6. Samples for iodine–131 analysis are taken from a tank truck, the route of which passes by farms widely dispersed over the area represented. Where there is no route representative of a large portion of the area, samples are collected from selected farms and combined. Presently, the sampling is on a monthly basis. Samples were collected weekly when iodine–131 was detectable in milk. A regional State Board of Health Laboratory is located in each area of the State where samples representing raw milk production are collected. For strontium–89, strontium–90 and cesium–137 analysis, monthly composite samples are prepared by each regional laboratory from a randomly selected 10 percent of the farms which have their milk regularly sampled for bacteriological analyses by the county health departments. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms—using locally grown feeds in the "West Florida" region—to larger farms using different types of grass and predominantly purchased feeds in the southern areas.

FIGURE 6.—FLORIDA MILK SAMPLING LOCATIONS

Analytical Procedures

Cesium–137 is determined by gamma scanning one liter or 3.5 liters of milk as received in a Marinelli beaker on a 4″ x 4″ NaI crystal and multichannel analyzer. The sample is then prepared for radiostrontium analysis by evaporating and ashing one liter.

Strontium is precipitated as a carbonate and stored for yttrium ingrowth. After the ingrowth period, yttrium is separated with carrier as an oxalate and counted in a low-background beta counter to determine strontium–90. Strontium is precipitated as carbonate and counted for total radiostrontium activity. Strontium–89 is then calculated by difference.

Results and Discussion

Tables 5, 6, and 7 present all available monthly average strontium–90, strontium–89 and cesium–137 concentrations in Florida milk during 1963. Iodine–131 results for 1963 appeared in the March 1964 issue of *RHD* (*3*).

TABLE 5.—STRONTIUM-89 IN FLORIDA RAW MILK, 1963

[Concentrations in pc/liter]

Month (1963)	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay	Southeast Florida	Average
January	57	49	30	23	22	43	38
February	29	46	43	49	40	30	39
March	43	46	52	70	66	69	58
April	64	55	30	77	33	64	54
May	61	59	58	44	47	64	56
June	53	61	54	26	22	26	40
July	25	21	18	19	23	18	21
August	22	18	17	16	19	17	18
September	19	13	18	16	14	20	17
October	8	6	8	8	10	6	8
November	3	6	8	7	4	6	6
December	4	5	<5	<5	8	<5	5
Average	32	32	28	30	26	31	30

TABLE 6.—STRONTIUM-90 IN FLORIDA RAW MILK, 1963

[Concentrations in pc/liter]

Month (1963)	West Florida	North Flordia	Northeast Florida	Central Florida	Tampa Bay	Southeast Florida	Average
January	4.6	6.5	5.4	4.5	3.8	6.1	5.1
February	6.3	4.7	15.0	4.3	6.2	3.1	6.6
March	4.1	3.8	7.1	17.3	13.8	16.1	10.4
April	9.6	6.1	4.3	7.2	6.8	9.5	7.2
May	15.0	14.7	17.7	16.1	13.1	15.4	15.3
June	11.2	17.5	6.8	16.0	5.2	11.9	11.4
July	6.0	4.0	6.0	4.0	9.0	4.0	5.5
August	7.0	6.0	11.0	9.0	12.0	7.0	8.7
September	10.0	9.0	10.0	12.0	8.0	7.0	9.3
October	20.0	22.0	11.0	12.0	9.0	7.0	13.5
November	15.0	12.0	7.0	11.0	9.0	11.0	10.8
December	16.0	9.0	8.0	8.0	8.0	12.0	10.2
Average	10.4	9.6	9.1	10.1	8.7	9.2	9.5

TABLE 7.—CESIUM-137 IN FLORIDA RAW MILK, APRIL–DECEMBER 1963

[Concentrations in pc/liter]

Month (1963)	West Florida	North Florida	Northeast Florida	Central Florida	Southeast Florida	Tampa Bay	Average
April	141	207	231	245	215	238	213
May	181	231	136	195	183	201	188
June	163	105	149	178	127	220	157
July	204	152	286	237	177	180	206
August	202	176	261	283	221	238	230
September	197	248	313	296	254	236	257
October	175	161	268	223	238	218	214
November	186	180	190	162	219	222	193
December	172	186	214	225	185	212	199
Average	180	183	228	227	202	218	206

Comparison of the Public Health Service Pasteurized Milk Network data for Tampa, Florida, for 1963 (May 1963–April 1964 issues of *RHD*) with the results from the Florida State Board of Health's Tampa Bay Area gives an indication of the agreement of the two sampling methods: raw milk composites from a sampling of farms and pasteurized milk composites from processing plants. These two sampling techniques provide estimates of the yearly average strontium–90 concentrations in raw and pasteurized milk that are within 38 percent of each other. Yearly average strontium–89 concentrations in raw and pasteurized milk have been within 14 percent of each other. For cesium–137 concentrations, the two methods gave average results within 15 percent of each other for April–December 1963 when analyses were being done.

4. Indiana Milk Network, June 1964

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (figure 7).

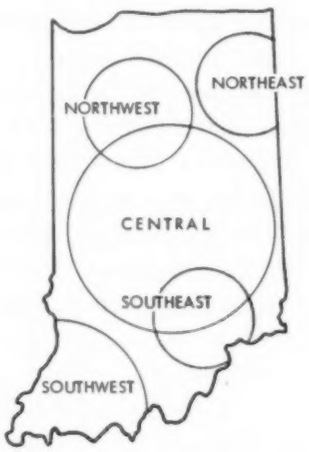

FIGURE 7.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*4*) is employed for strontium–89 and strontium–90 analyses. Minimum detectable levels for strontium–89 and strontium–90 are about 5 and 1 pc/liter, respectively. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137 and barium–140. Analyses of counting statistics indicate that the lower limit of detectability for both iodine–131 and barium–140 is 5 pc/liter. Cesium–137 analyses are subject to a 6 percent error at the 100 pc/liter level. Additional factors such as drift of the analyzer and calibration factors will increase these limits to some extent.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 8.

TABLE 8.—RADIONUCLIDES IN INDIANA MILK, JUNE 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{90}	Cs^{137}
Northeast	1.17	1,280	21	110
Southeast	1.17	1,170	19	105
Central	1.17	1,230	19	80
Southwest	[b]	[b]	[b]	[b]
Northwest	1.17	1,240	22	120
State average	1.17	1,230	21	105

[a] The monthly average iodine-131, barium-140, and strontium-89 concentrations at each station was zero.
[b] No sample collected.

5. New York Milk Network, April 1964

Division of Environmental Health Services
State of New York Department of Health

Milk samples collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York, and Syracuse (figure 8) are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137 and barium–lanthanum–140 at all stations except Massena, where samples are composited bi-weekly, and at New York where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*5*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

FIGURE 8.—NEW YORK MILK SAMPLING LOCATIONS

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentially estimated by a second count 40 hours later to determine the rate of ingrowth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 9.

TABLE 9.—RADIONUCLIDES IN NEW YORK MILK, APRIL 1964 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89	Strontium-90	Cesium-137
Albany	<3	19	126
Buffalo	4	13	112
Massena	8	29	187
Newburgh	4	18	137
New York City	4	23	129
Syracuse	3	19	108
Average	4	20	133

[a] The monthly average I^{131} and $Ba\text{-}La^{140}$ (in equilibrium) at each station was <20 pc/liter.

6. Pennsylvania Milk Network April-June 1964

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 9). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Iodine–131 analyses were begun in September 1961, and strontium–90 analyses were started in April 1963. The gamma analyses of these samples for potassium–40, iodine–131, cesium–137, and barium–140-lanthanum–140 was begun in March 1964.

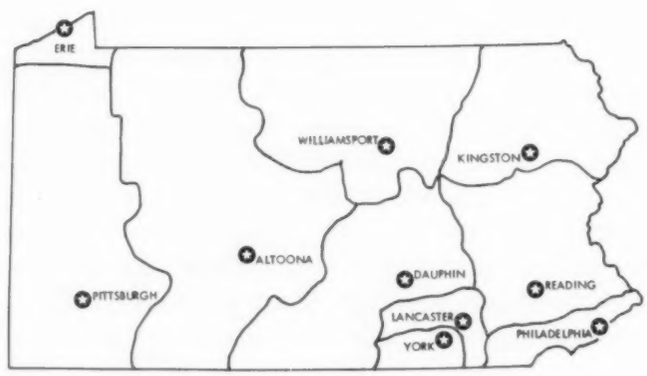

FIGURE 9.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter, *et al.* (*4*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low background proportional counter.

The monthly average radionuclide levels in pasteurized milk are shown in table 10.

TABLE 10.—STRONTIUM-90 IN PENNSYLVANIA MILK, APRIL–JULY 1964

[Concentrations in pc/liter]

Sampling location	April	May	June	July
ltoona	20	42	37	43
auphin	19	39	27	26
rie	21	37	33	34
ingston	21	30	36	36
ancaster	18	29	24	22
hiladelphia	21	35	31	38
ittsburgh	21	41	38	39
eading	16	29	25	24
illiamsport	17	32	27	39
ork	15	25	20	25
tate average	18.9	33.9	29.8	32.6

7. Canadian Milk Network [3] June 1964

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 10) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies and are combined into weekly composites and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical Procedures

Radiochemical methods are used for the analysis of iodine–131 (*6*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450° C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method, the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

[3] Data from *Radiation Protection Programs, Vol. 2, No. 7:* 25–29, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (July 1964).

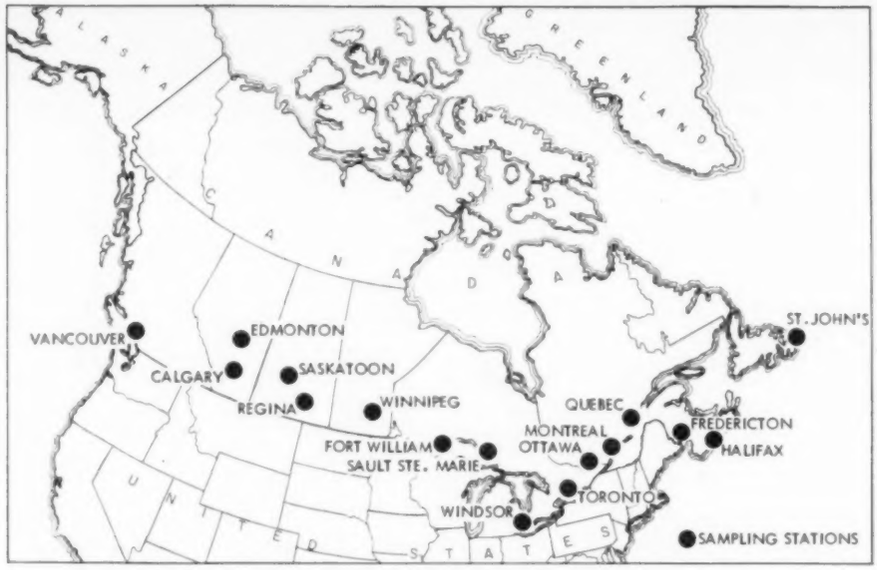

FIGURE 10.—CANADIAN MILK SAMPLING STATIONS

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium–137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 11.

TABLE 11.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 12 presents monthly averages of strontium–90, cesium–137 and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had <5 pc/liter. Figure 11 shows

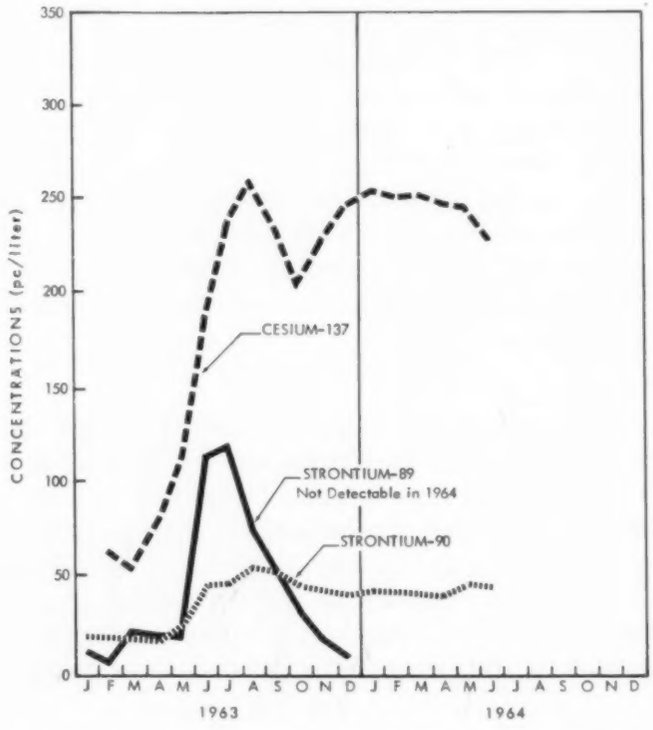

FIGURE 11.—NETWORK AVERAGE STRONTIUM–89, STRONTIUM–90, AND CESIUM–137 CONCENTRATIONS IN CANADIAN WHOLE MILK

he variation of the network average of the adionuclide concentration in Canadian whole nilk.

TABLE 12.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JUNE 1964

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
algary	1.46	1.5	44.4	184
dmonton	1.39	1.6	40.0	177
t. William	1.40	1.6	66.8	314
redericton	1.43	1.6	47.9	271
alifax	1.47	1.6	54.7	317
lontreal	1.42	1.7	37.3	198
ttawa	1.41	1.6	29.0	155
uebec	1.42	1.6	52.1	282
egina	1.35	1.6	36.0	156
t. John's, Nfld	1.35	1.7	58.3	339
askatoon	1.36	1.6	30.5	116
ault Ste. Marie	1.38	1.6	52.8	257
oronto	1.42	1.6	17.9	114
ancouver	1.49	1.6	55.5	488
indsor	1.44	1.6	20.4	109
innipeg	1.22	1.6	35.7	159
verage	1.40	1.6	42.5	227

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MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, JULY 1963–JUNE 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.,* annual average concentrations of strontium–89, strontium–90, and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all sources. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and to one-third of the RPG for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pastuerized Milk Network are presented in table 1. The data in table 1 are calculated as follows: Results from all samples collected in each week

(Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

Monthly variations of radionuclide concentrations in milk are influenced by a number of

[1] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously, 5 pc/liter was used for calculating the averages.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Cesium-137	
		June 1963–May 1964	July 1963–June 1964	June 1963–May 1964	July 1963–June 1964	June 1963–May 1964	July 1963–June 1964
Ala:	Montgomery	21	14	23	23	91	91
Alaska:	Palmer	25	20	25	26	157	164
Ariz:	Phoenix	4	3	4	4	25	26
Ark:	Little Rock	47	31	47	46	167	157
Calif:	Sacramento	12	5	9	9	60	56
	San Francisco	16	8	12	11	69	65
Colo:	Denver	20	14	20	20	95	94
Conn:	Hartford	18	13	27	25	184	182
Del:	Wilmington	20	12	27	26	150	145
D. C:	Washington	24	15	20	20	106	99
Fla:	Tampa	12	9	15	15	241	246
Ga:	Atlanta	34	23	33	33	161	159
Hawaii:	Honolulu	10	6	11	11	83	83
Idaho:	Idaho Falls	43	27	31	30	187	189
Ill:	Chicago	16	10	21	21	130	128
Ind:	Indianapolis	18	13	24	23	112	110
Iowa:	Des Moines	35	19	28	27	101	98
Kans:	Wichita	30	14	23	23	81	75
Ky:	Louisville	50	30	36	35	122	113
La:	New Orleans	38	25	49	50	163	161
Maine:	Portland	24	19	34	35	235	242
Md:	Baltimore	33	19	23	23	133	123
Mass:	Boston	28	22	38	38	270	271
Mich:	Detroit	14	10	21	20	128	127
	Grand Rapids	15	11	23	22	137	138
Minn:	Minneapolis	44	27	35	35	171	168
Miss:	Jackson	36	26	40	41	120	120
Mo:	Kansas City	43	21	30	29	95	90
	St. Louis	31	17	26	24	96	93
Mont:	Helena	37	27	32	33	214	217
Nebr:	Omaha	34	21	28	28	109	106
Nev:	Las Vegas	12	10	11	12	84	87
N. H:	Manchester	25	19	37	36	288	286
N. J:	Trenton	17	12	22	21	141	137
N. Mex:	Albuquerque	13	8	12	12	56	56
N. Y:	Buffalo	18	13	24	23	161	161
	New York	27	19	32	32	194	193
	Syracuse	21	15	26	24	163	171
N. C:	Charlotte	39	25	35	35	134	129
N. Dak:	Minot	66	38	60	61	163	163
Ohio:	Cincinnati	21	14	27	26	105	104
	Cleveland	19	13	23	23	127	125
Okla:	Oklahoma City	28	16	24	24	89	82
Ore:	Portland	34	21	32	33	175	177
Pa:	Philadelphia	18	12	24	23	142	136
	Pittsburgh	27	18	32	32	174	171
P. R:	San Juan	17	11	13	13	85	80
R. I:	Providence	20	14	29	28	190	191
S. C:	Charleston	21	13	30	30	142	140
S. Dak:	Rapid City	52	35	45	45	174	169
Tenn:	Chattanooga	49	33	42	43	156	149
	Memphis	36	22	34	34	94	87
Tex:	Austin	11	7	10	10	49	47
	Dallas	21	12	21	21	81	76
Utah:	Salt Lake City	29	22	28	28	193	194
Vt:	Burlington	23	18	31	31	210	213
Va:	Norfolk	23	14	23	23	109	106
Wash:	Seattle	31	22	28	29	159	167
	Spokane	34	23	31	31	154	155
W. Va:	Charleston	40	26	31	30	108	102
Wis:	Milwaukee	15	10	21	20	142	143
Wyo:	Laramie	29	20	24	23	120	118
Network average		27	18	27.0	26.8	138	136

combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, JANUARY–MARCH 1964

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Total Diet Sampling Network in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 23 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point), except those at Los Angeles, California, and Columbia, Mississippi, is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from the Pasteurized Milk Network supplement the findings for the Institutional Diet Sampling Program.

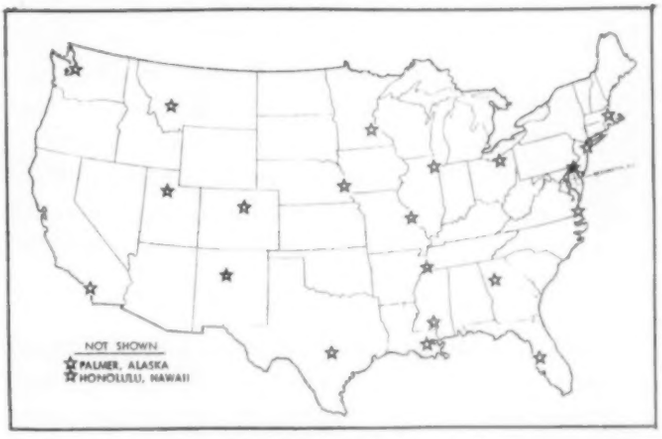

FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS

Sampling Procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month.

Each day's sample is kept frozen during the collection period. After collection, the total sample is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

The sample for each day is packaged in three parts: (1) solid food and semi-solid foods minus those portions that would not ordinarily be eaten; (2) fluid milk; (3) other liquids such as soups, soft drinks, coffee, and tea. Drinking water from each station is analyzed routinely, but the data are not included in this report. A record of the contents of each meal and the approximate amount of each item is made at the institution and sent with the sample.

Analytical Procedures

Because calcium compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Total weight is accurately determined in the laboratory. Stable calcium and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy; (2) chemical separation of strontium–89 and strontium–90 with subsequent counting; and (3) radium–226 analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan for iodine–131, cesium–137, and barium–140 are 10 pc/kg. Approximate minimum detectable concentrations for strontium–89, strontium–90 and radium–226 are: 5, 1 and 1 pc/kg, respectively. Since a constant weight of food is analyzed, the minimum detectable level on a per day basis (pc/day) will be dependent on the food intake.

Data

Table 1 gives the results of the laboratory analyses of the food samples in terms of concentrations of various radionuclides and stable elements, expressed as picocuries per kilogram of diet or grams per kilogram of diet, respectively.

Table 2 presents the dietary intake data expressed on a per-day basis from January through March 1964 for the 23 institutions from which samples were received. The intake values in this table were obtained by multiplying the food consumption in kg/day (column 4 of table 2) times the concentration values in grams or picocuries per kilogram of diet given in table 1. Also contained in the table is the range of ages of the children from which samples are being obtained. The reported radionuclide concentrations of these samples are extrapolated to the midpoint of the sample collection period.

Certain of the radioanalyses are reported by the laboratories as being "less-than" (<) a specified value. For data computations, the method employed is to use a zero for <10 pc/kg values for iodine–131 and barium–140. A 2.5 pc/kg was substituted for a <5 pc/kg of strontium–89; 0.5 was substituted for <1 pc/kg of radium–226.

The data are also presented graphically in figure 2 as a distribution of all sample values observed during the three months versus daily intake. The number of values reported during this quarter in each range is ploted as a frequency-distribution bar chart. The number of stations used in constructing these graphs was 22, 20, and 23 for the months of January, February, and March 1964, respectively. Therefore, the total number of samples represented in each distribution (a-e) is 65.

Discussion of Data

From table 2 it is apparent that the total intake ranged between 1.17 and 3.43 kg/day, with an average of 2.0 kg/day during this quarter. The frequency distribution bar chart (figure 2-a) shows that 48 samples, or 74 percent, weighed between 1.50 and 2.50 kg/day, inclusive.

TABLE 1.—CONCENTRATION OF RADIONUCLIDES AND STABLE ELEMENTS IN INSTITUTIONAL DIETS, JANUARY–MARCH 1964 [a]

[Based on a 7-day composite sample]

Location of Institutions		Month (1964)	Calcium	Potassium	Radium-226	Strontium-89	Strontium-90	Cesium-137
			(grams per kilogram)		(picocuries per kilogram)			
Alaska:	Palmer	Jan	0.6	1.6	0.6	5	13	120
		Feb	0.7	1.8	0.7	10	17	135
		Mar	0.7	1.7	0.5	10	40	120
California:	Los Angeles	Jan	0.5	1.7	0.8	<5	6	65
		Feb	0.6	1.7	1.1	<5	8	70
		Mar	0.6	2.0	0.7	<5	14	50
Colorado:	Denver	Jan	0.6	1.6	0.6	5	11	65
		Feb	0.7	1.4	0.6	5	12	70
		Mar	0.6	1.4	0.5	<5	13	50
Delaware:	Wilmington	Jan	[b]—	—	—	—	—	—
		Feb	—	—	—	—	—	—
		Mar	0.7	1.6	0.3	<5	15	110
Florida:	Tampa	Jan	0.9	1.4	[c] 1.8	<5	15	225
		Feb	0.6	1.1	[c] 1.4	<5	15	130
		Mar	1.0	1.7	[c] 1.8	<5	14	105
Georgia:	Atlanta	Jan	0.4	1.0	[c] 0.6	5	13	60
		Feb	0.4	0.9	[c] 1.2	<5	16	55
		Mar	0.4	0.8	[c] 1.6	<5	11	55
Hawaii:	Honolulu	Jan	0.5	1.6	1.1	25	9	65
		Feb	0.5	1.6	1.8	5	12	70
		Mar	0.4	1.4	1.1	<5	10	75
Illinois:	Chicago	Jan	0.8	1.7	0.6	<5	15	120
		Feb	0.7	1.4	0.3	<5	16	110
		Mar	0.8	1.7	0.3	<5	15	120
Louisiana:	New Orleans	Jan	0.7	1.4	[c] 2.4	5	21	110
		Feb	0.6	1.5	[c] 2.5	5	26	140
		Mar	0.6	1.6	[c] 1.5	<5	31	140
Massachusetts:	Boston	Jan	0.8	1.6	0.2	10	23	215
		Feb	0.8	1.6	0.2	<5	26	200
		Mar	0.6	1.6	0.3	<5	19	170
Minnesota:	Minneapolis	Jan	0.4	1.6	0.5	<5	15	95
		Feb	0.5	1.6	0.8	<5	14	110
		Mar	0.5	1.5	0.5	10	19	110
Mississippi:	Columbia	Jan	0.8	1.4	[c] 3.1	<5	23	110
		Feb	0.8	1.4	[c] 2.6	5	25	120
		Mar	0.9	1.5	[c] 2.5	10	35	200
Missouri:	St. Louis	Jan	0.6	1.4	2.0	10	17	60
		Feb	0.7	1.6	0.7	10	33	75
		Mar	0.6	1.3	0.7	5	15	70
Montana:	Helena	Jan	0.5	1.2	0.5	<5	14	105
		Feb	0.5	1.2	0.4	<5	15	105
		Mar	0.6	0.9	0.3	10	27	110
Nebraska:	Omaha	Jan	0.7	1.5	0.4	<5	15	65
		Feb	0.7	1.5	0.4	<5	17	70
		Mar	0.8	1.5	[d]	<5	22	80
New Mexico:	Albuquerque	Jan	0.7	1.7	0.8	<5	14	45
		Feb	0.9	1.6	0.7	5	11	30
		Mar	0.9	1.4	0.4	<5	23	40
New York:	New York	Jan	[e] 1.0	[e] 1.7	[e] 0.3	[e] <5	[e] 19	[e] 85
		Feb	[e]	[e]	[e]	[e]	[e]	[e]
		Mar	0.6	1.6	0.6	<5	16	115
Ohio:	Cleveland	Jan	0.5	1.7	0.6	<5	12	95
		Feb	0.7	1.7	0.6	<5	16	100
		Mar	0.6	1.7	0.3	<5	12	105
Tennessee:	Memphis	Jan	0.8	1.2	[c] 1.3	<5	22	65
		Feb	0.5	1.5	[c] 0.5	<5	12	55
		Mar	0.7	1.5	[c] 2.4	<5	20	65
Texas:	Austin	Jan	0.6	1.4	[c] 1.2	<5	9	45
		Feb	0.5	1.3	[c] 2.2	<5	10	45
		Mar	0.5	1.2	[c] 1.5	<5	10	30
Utah:	Salt Lake City	Jan	0.5	1.8	0.4	<5	12	135
		Feb	0.6	1.5	0.2	5	14	140
		Mar	0.6	1.6	0.4	<5	16	140
Virginia:	Norfolk	Jan	0.5	1.1	[c] 2.3	5	12	60
		Feb	0.5	1.2	[c] 1.5	5	13	60
		Mar	0.6	1.2	[c] 1.0	<5	11	60
Washington:	Seattle	Jan	0.6	1.5	0.7	<5	16	110
		Feb	0.6	1.4	0.8	5	14	90
		Mar	0.2	1.4	0.9	<5	16	100
Monthly average		Jan	0.6	1.5	[f] 0.7	<5	15	95
		Feb	0.6	1.5	[f] 0.7	<5	16	95
		Mar	0.6	1.5	[f] 0.5	<5	18	95

[a] The monthly average iodine-131 and barium-140 concentrations were <10 pc/kg during this period. [b] Dash indicates station not in operation. [c] Total radium values, not radium-226. [d] Indicates no analysis. [e] Indicates no sample. [f] Average for radium-226; does not include total radium.

TABLE 2.—INSTITUTIONAL DAILY DIETARY INTAKES (BASED ON A 7-DAY COMPOSITE SAMPLE), JANUARY–MARCH 1964 [a]

Location of Institutions		Age (years)	Month (1964)	Total Weight (kg/day)	Calcium	Potassium	Radium-226	Strontium-89	Strontium-90	Cesium-137
					(grams per day)		(picocuries per day)			
Alaska:	Palmer	6–16	Jan	1.57	0.9	2.5	1	10	20	190
			Feb	1.49	1.0	2.7	1	15	25	200
			Mar	1.25	0.9	2.1	1	10	50	150
California:	Los Angeles	12–18	Jan	2.02	1.0	3.4	2	5	12	130
			Feb	1.94	1.2	3.3	2	5	16	135
			Mar	1.44	0.9	2.9	1	5	20	70
Colorado:	Denver	4–17	Jan	2.63	1.6	4.2	2	15	29	170
			Feb	2.69	1.9	3.8	2	15	32	190
			Mar	3.10	1.9	4.3	2	10	40	155
Delaware:	Wilmington	6–14	Jan	[b]—	—	—	—	—	—	—
			Feb	—	—	—	—	—	—	—
			Mar	2.18	1.5	3.5	1	5	33	240
Florida:	Tampa	6–18	Jan	2.02	1.8	2.9	[c] 3.6	10	30	450
			Feb	2.88	1.8	3.0	[c] 4.0	10	44	375
			Mar	2.14	2.1	3.6	[c] 3.8	10	30	220
Georgia:	Atlanta	6–18	Jan	2.26	0.9	2.2	[c] 1.5	15	29	130
			Feb	2.39	1.0	2.3	[c] 2.9	5	38	130
			Mar	2.45	1.3	2.9	[c] 5.7	10	39	190
Hawaii:	Honolulu	7–20	Jan	1.90	1.0	3.0	2	50	17	125
			Feb	[d]—	—	—	—	—	—	—
			Mar	1.72	0.7	2.4	2	5	17	130
Illinois:	Chicago	6–15	Jan	1.17	1.0	2.0	1	0	17	135
			Feb	1.96	1.5	2.9	0	0	30	220
			Mar	1.76	1.3	2.9	0	0	26	215
Louisiana:	New Orleans	7–18	Jan	2.61	1.8	3.7	[c] 6.2	20	55	285
			Feb	2.65	1.7	4.0	[c] 6.4	20	69	370
			Mar	2.35	1.4	3.8	[c] 3.6	10	72	325
Massachusetts:	Boston	6–14	Jan	2.31	1.9	3.7	0	20	52	495
			Feb	1.48	1.2	2.5	0	5	38	300
			Mar	1.70	1.0	2.7	1	5	32	285
Minnesota:	Minneapolis	[e] <1–16	Jan	1.64	0.7	2.6	1	5	25	155
			Feb	1.61	0.8	2.6	1	5	23	175
			Mar	1.67	0.8	2.5	1	15	32	185
Mississippi:	Columbia	10–19	Jan	2.23	1.9	3.2	[c] 7.0	10	51	250
			Feb	1.81	1.4	2.5	[c] 4.7	10	46	215
			Mar	2.04	1.8	3.5	[c] 5.2	20	72	405
Missouri:	St. Louis	7–18	Jan	2.64	1.6	3.7	5	25	45	160
			Feb	2.49	1.7	4.0	2	25	82	185
			Mar	3.00	1.8	3.9	2	15	45	210
Montana:	Helena	6–17	Jan	2.60	1.3	3.1	1	5	36	275
			Feb	2.60	1.3	3.1	1	5	39	275
			Mar	2.20	1.3	2.0	1	20	59	240
Nebraska:	Omaha	8–18	Jan	2.09	1.5	3.1	1	5	31	135
			Feb	1.74	1.2	2.6	1	5	30	120
			Mar	2.40	1.9	3.6	[f]	5	53	190
New Mexico:	Albuquerque	5–15	Jan	2.04	1.4	3.5	2	5	29	90
			Feb	2.16	1.9	3.5	2	10	24	65
			Mar	2.00	1.8	2.8	1	5	46	80
New York:	New York	8–15	Jan	1.82	1.9	3.1	1	5	35	160
			Feb	[g]	[g]	[g]	[g]	[g]	[g]	[g]
			Mar	1.53	0.9	2.3	1	0	25	175
Ohio:	Cleveland	6–15	Jan	2.13	1.2	3.5	1	5	26	210
			Feb	2.32	1.5	4.0	1	5	35	230
			Mar	2.09	1.3	3.5	1	5	25	220
Tennessee:	Memphis	8–18	Jan	1.96	1.6	2.3	[c] 2.5	10	44	125
			Feb	1.82	0.8	2.7	[c] 1.0	5	22	100
			Mar	1.61	1.1	2.4	[c] 3.9	5	30	105
Texas:	Austin	6–19	Jan	1.79	1.0	2.4	[c] 2.2	5	16	80
			Feb	1.98	1.0	2.5	[c] 4.4	5	19	95
			Mar	1.96	0.9	2.4	[c] 3.0	5	19	65
Utah:	Salt Lake City	12–18	Jan	1.34	0.7	2.4	1.0	5	16	180
			Feb	1.50	0.9	2.2	0.0	10	21	210
			Mar	1.51	0.9	2.4	1.0	5	24	210
Virginia:	Norfolk	10–18	Jan	2.12	1.2	2.4	[c] 4.7	15	26	130
			Feb	2.00	1.0	2.4	[c] 3.1	10	28	120
			Mar	2.14	1.2	2.6	[c] 2.3	5	25	130
Washington:	Seattle	6–18	Jan	1.96	1.2	2.9	1.0	5	31	215
			Feb	1.92	1.2	2.7	2.0	10	27	175
			Mar	1.86	0.4	2.6	2.0	5	30	185
Monthly average			Jan	2.04	1.3	3.0	[h] 1.0	10	31	195
			Feb	2.07	1.3	3.0	[h] 1.0	10	34	195
			Mar	2.05	1.3	2.9	[h] 1.0	10	37	190

[a] Iodine-131 and barium-140 intakes at each institution were zero during this period. [b] Dash indicates station not in operation. [c] Total radium, not radium-226. [d] Sample weight unknown. [e] Food samples not collected for children too young for solid diets. [f] No analysis performed. [g] No sample available. [h] Average for radium-226; does not include total radium.

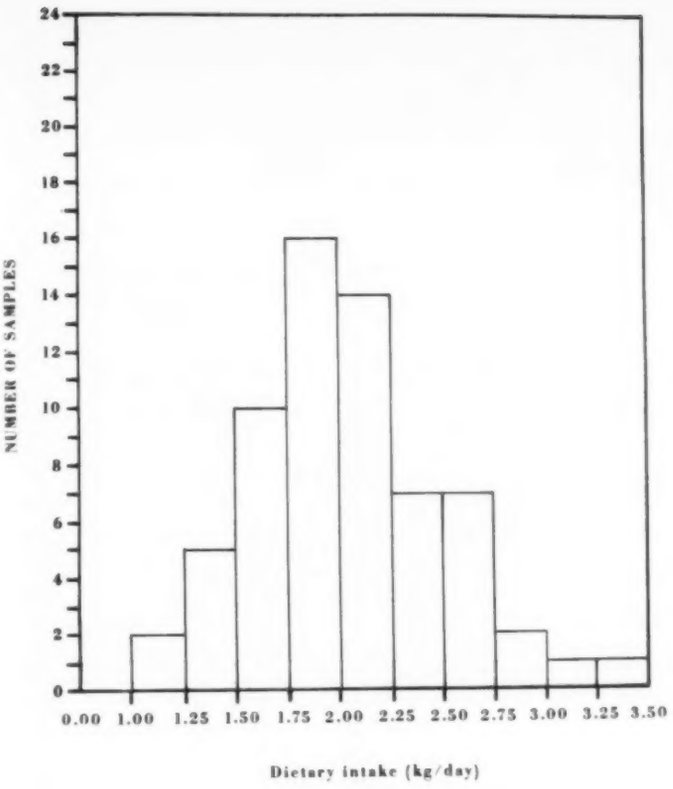

FIGURE 2-a.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS DIETARY INTAKE OF FOOD IN INSTITUTIONAL DIETS, JANUARY–MARCH 1964

The calcium intake (figure 2-b) ranged between 0.4 and 2.1 g/day, with 11 percent of the values being less than 0.8 g/day. Ninety-five percent of the samples analyzed for potassium (figure 2-c) showed that the intake was between 2.0 and 4.0 g/day.

Of the 43 samples analyzed for radium–226, only one intake value exceeded 2 pc/day; this was the St. Louis, Missouri sample for January, which contained 5 pc/day. The Federal Radiation Council (FRC) range II for radium–226 is 2 to 20 pc/day (*3*).

Strontium–89 intake averaged 10 pc/day during the first quarter. More samples contained nondetectable concentrations of strontium–89 during this quarter than in the previous one. Sixty-two sample results were 20 pc/day or less for strontium–89. Two results were 25 pc/day and one was 50 pc/day. For purposes of comparison the FRC range II for strontium–89 is 200 to 2000 pc/day (*3*).

The maximum strontium–90 intake (figure 2-d) during this quarter was 82 pc/day. Again for comparison, 75 percent of the values were between 10 and 40 pc/day. The average of all institutions increased from 31 pc/day in January to 37 pc/day in March. The FRC range II for strontium–90 is 20 to 200 pc/day (*3*).

Although the intake of cesium–137 (figure 2-e) ranged from 65 to 495 pc/day, the distribution shows a peak between 120 and 240 pc/day formed by 69 percent of the results. The average of all institutions is seen to have remained steady at 190 to 195 pc/day during the first three months in 1964.

Both barium–140 and iodine–131 were below the limits of detectability during this quarter.

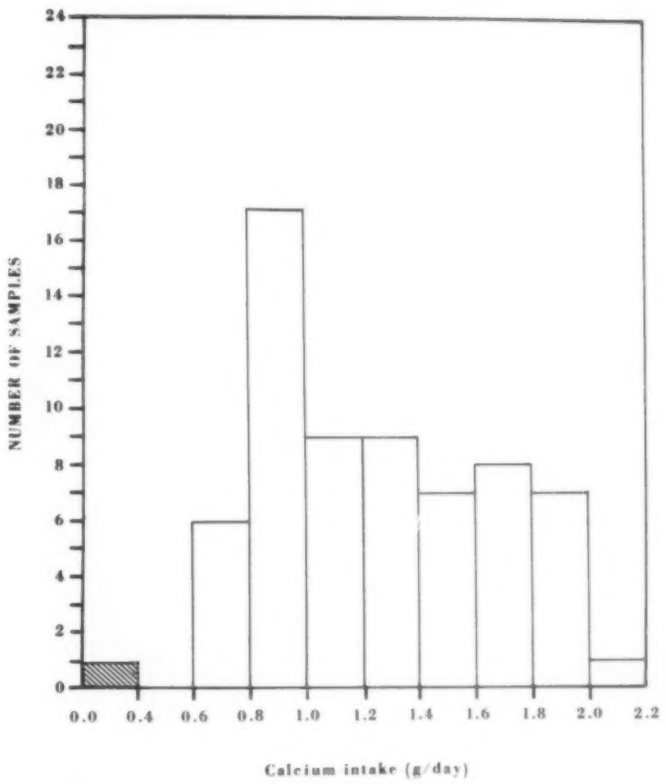

FIGURE 2-b.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE OF CALCIUM IN INSTITUTIONAL DIETS, JANUARY–MARCH 1964
(Shaded portions show extended ranges)

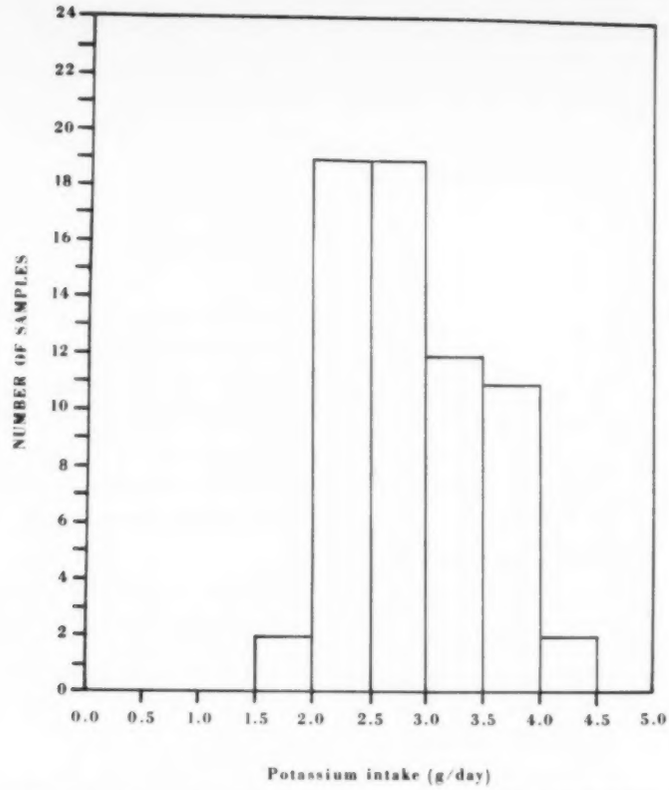

FIGURE 2-c.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE OF POTASSIUM IN INSTITUTIONAL DIETS, JANUARY–MARCH 1964

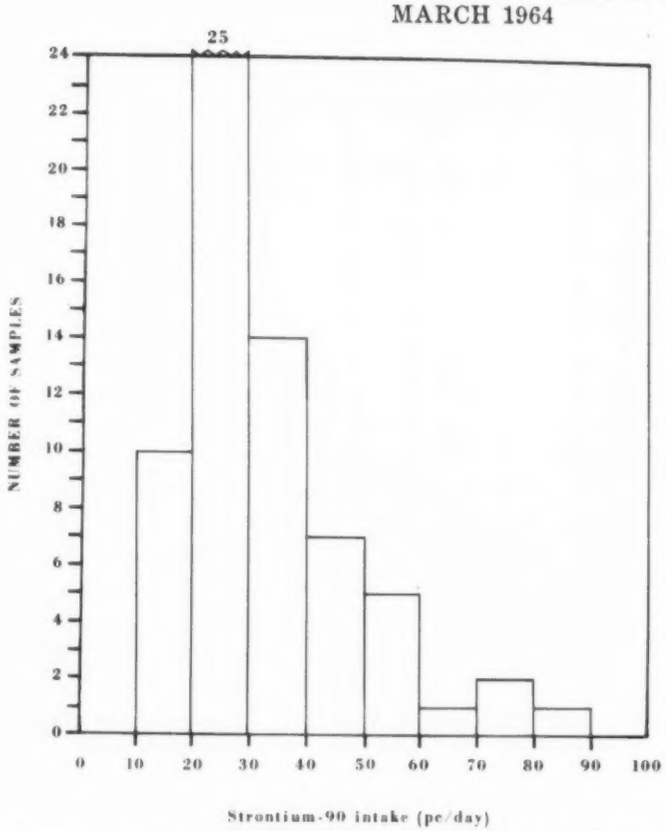

FIGURE 2-d.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE OF STRONTIUM-90 IN INSTITUTIONAL DIETS, JANUARY–MARCH 1964

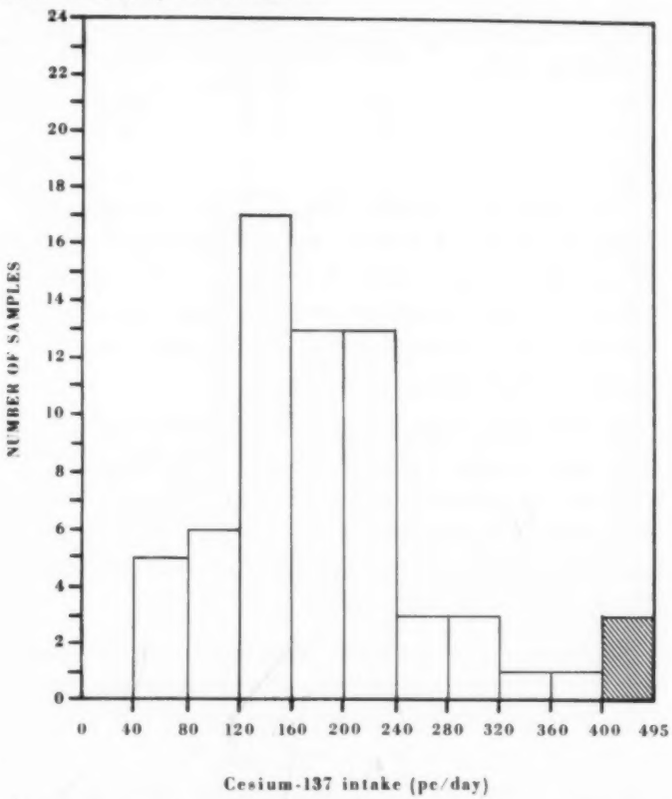

FIGURE 2-e.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE OF CESIUM-137 IN INSTITUTIONAL DIETS, JANUARY–MARCH 1964

(Shaded portions show extended ranges)

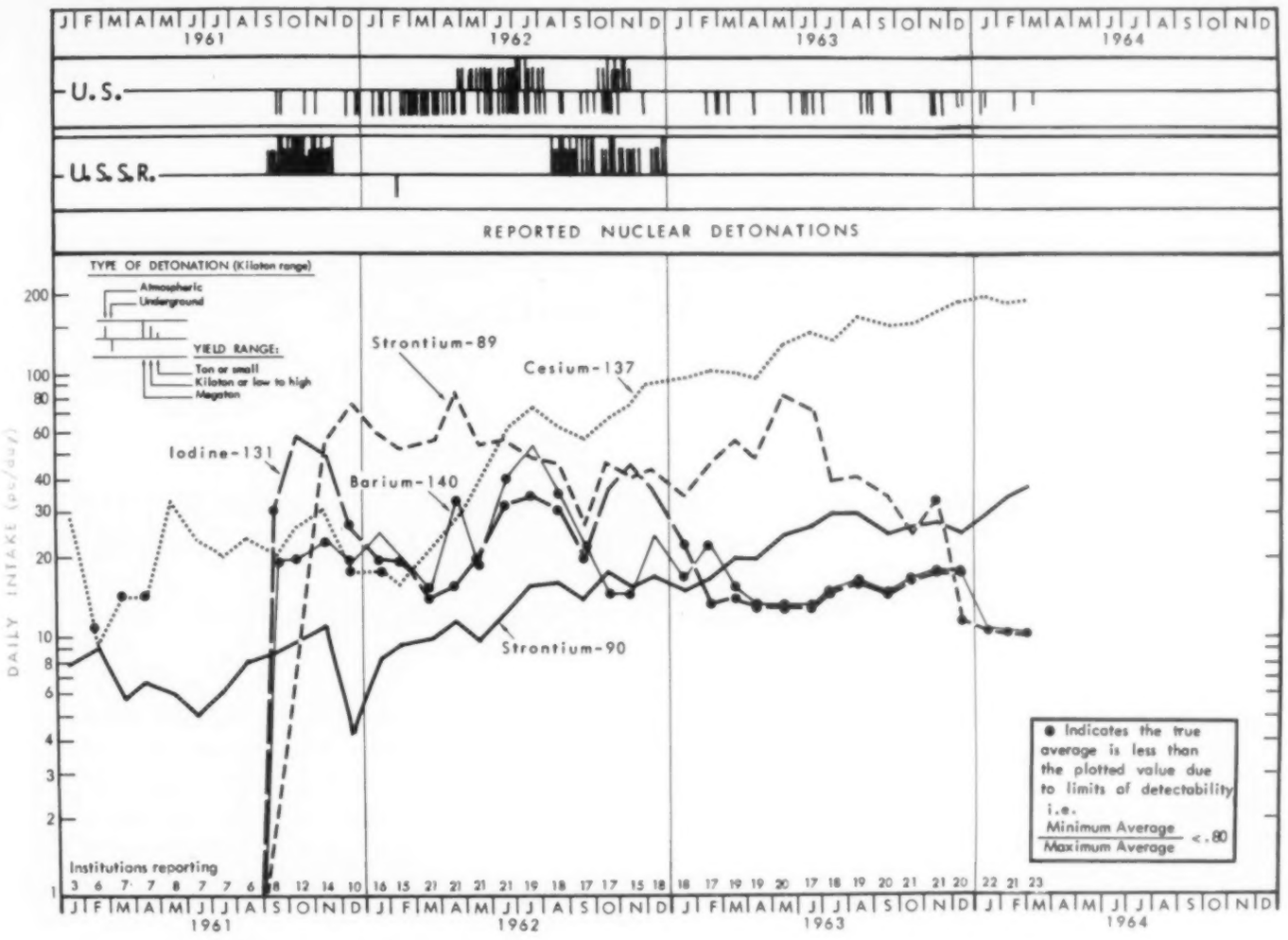

FIGURE 3.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52:* 1391–400 (September 1962).

(*2*) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers, *Annual Review of Pharmacology, 1:* 369–96 (1961).

(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2,* Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1962	*April 1963*
October–December 1962	*July 1963*
January–March 1963	*September 1963*
April–June 1963	*December 1963*
July–September 1963	*March 1964*
October–December 1963	*July 1964*

Section III—Water

STRONTIUM-90 AND GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, APRIL 1964

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has expanded to 130 stations as of September 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the system provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be exposed. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–7*).

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from most stations. Weekly analyses are conducted for stations located downstream from known potential sources of radioactive waste, as well as at all newly established stations for the first year of operation.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, APRIL 1964

a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Results

Table 1 presents April 1964 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the system's "Annual Compilation of Data" (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter.

A geographical perspective of the radioactivity in surface water is obtainable from the numbers printed near the stations as shown in figure 1, which gives the April 1964 average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. Results for the years 1957–1962 have been summarized by Weaver *et al.* (*9*).

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, APRIL 1964

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	9	9	18	1	0	1
Animas River:						
Cedar Hill, N. Mex	27	16	43	6	2	8
Apalachicola River:						
Chattahoochee, Fla	6	9	15	0	0	0
Arkansas River:						
Coolidge, Kansas	52	91	143	2	21	23
Ponca City, Okla	92	33	125	10	5	15
Fort Smith, Ark	80	31	111	15	1	16
Little Rock, Ark	35	21	56	4	<1	4
Pendleton Ferry, Ark	63	26	89	6	0	6
Bear River:						
Preston, Idaho	4	56	60	0	0	0
Big Horn River:						
Hardin, Mont	243	36	279	38	20	58
Big Sioux River:						
Sioux Falls, S. Dak	18	73	91	0	2	2
Chattahoochee River:						
Atlanta, Ga	9	10	19	0	0	0
Columbus, Ga	15	9	24	1	0	0
Lanett, Ala	18	11	29	1	0	0
Chena River:						
Fairbanks, Alaska	0	3	3	0	0	0
Clearwater River:						
Lewiston, Idaho	6	11	17	0	0	0
Clinch River:						
Clinton, Tenn	4	10	14	0	<1	<1
Kingston, Tenn	15	85	100	0	0	0
Colorado River:						
Loma, Colo	89	32	121	11	6	17
Page, Ariz	1	34	35	0	9	9
Boulder City, Nev	3	35	38	0	14	14
Parker Dam, Calif-Ariz	1	16	17	0	4	4
Yuma, Ariz	0	6	6	0	6	6
Columbia River:						
Northport, Wash	0	8	8	0	1	1
Wenatchee, Wash	0	6	6	0	1	1
Pasco, Wash	162	692	854	0	1	1
McNary Dam, Ore	44	225	269	0	1	1
Bonneville, Ore	38	236	274	0	<1	<1
Clatskanie, Ore	25	145	170	0	0	0
Connecticut River:						
Wilder, Vt	6	13	19	0	0	0
Northfield, Mass	12	11	23	1	0	1
Enfield Dam, Conn	4	10	14	0	0	0
Cuyahoga River:						
Cleveland, Ohio	12	32	44	0	0	0
Delaware River:						
Martins Creek, Pa	5	10	15	0	0	0
Trenton, N. J	5	8	13	0	0	0
Philadelphia, Pa	14	11	25	1	1	2
Escambia River:						
Century, Fla	5	8	13	0	0	0
Great Lakes:						
Duluth, Minn	1	9	10	0	0	0
Sault Ste. Marie, Mich	2	6	8	0	0	0
Milwaukee, Wisc	3	9	12	0	0	0
Gary, Ind	1	8	9	0	0	0
Port Huron, Mich	2	9	11	0	0	0
Detroit, Mich	1	8	9	0	0	0
Buffalo, N. Y	6	15	21	0	0	0
Green River:						
Dutch John, Utah	2	29	31	0	4	4
Hudson River:						
Poughkeepsie, N. Y	3	13	16	0	0	0
Illinois River:						
Peoria, Ill	13	34	47	1	0	1
Grafton, Ill	24	29	53	2	1	3
Kanawha River: Winfield Dam, W. Va	6	7	13	0	0	0
Kansas River:						
De Soto, Kans	123	50	173	12	2	14
Klamath River:						
Keno, Ore	8	12	20	0	0	0
Little Miami River:						
Cincinnati, Ohio	21	28	49	2	1	3
Maumee River:						
Toledo, Ohio	64	38	102	3	0	3
Merrimack River:						
Lowell, Mass	6	11	17	0	0	0
Mississippi River:						
St. Paul, Minn	15	35	50	0	2	2
Dubuque, Iowa	19	22	41	1	1	2
Burlington, Iowa	12	1	13	1	0	1
E. St. Louis, Ill	57	28	85	3	0	3
Cape Girardeau, Mo	65	28	93	6	2	8
W. Memphis, Ark	44	17	61	2	0	2
Vicksburg, Miss	33	17	50	2	0	2
Delta, La	26	17	43	3	1	4
New Orleans, La	38	18	56	6	0	6
Missouri River:						
Williston, N. Dak	31	28	59	4	6	10
Bismarck, N. Dak	11	30	41	1	4	5
Yankton, S. Dak	4	29	33	0	4	4
Omaha, Nebr	104	30	134	17	4	21
St. Joseph, Mo	98	31	129	6	3	9
Kansas City, Kans	243	31	274	26	4	30
Missouri City, Mo	151	25	176	34	2	36
St. Louis, Mo	128	28	156	24	2	26
Monongahela River:						
Pittsburgh, Pa	26	7	33	4	0	4
North Platte River:						
Henry, Nebr	11	45	56	0	28	28
Ohio River:						
Toronto, Ohio	15	12	27	1	0	1
Addison, Ohio	18	11	29	1	0	1
Huntington, W. Va	41	11	52	3	0	3
Cincinnati, Ohio	18	14	32	1	0	1
Louisville, Ky	43	15	58	5	0	5
Evansville, Ind	31	13	44	3	0	3
Cairo, Ill	46	17	63	8	0	8
Ouachita River:						
Bastrop, La	44	26	70	5	1	6
Pend Oreille River:						
Albeni Falls Dam, Idaho	2	7	9	0	1	1
Platte River:						
Plattsmouth, Nebr	296	52	348	28	6	34
Potomac River:						
Williamsport, Md	7	7	14	0	0	0
Great Falls, Md	14	10	24	1	0	1
Washington, D.C	5	10	15	<1	<1	<1
Rainy River:						
Baudette, Minn	12	39	51	0	0	0
International Falls, Minn	4	26	30	0	1	1
Raritan River:						
Perth Amboy, N. J. (5 ft. Below Surface)	5	11	16	0	2	2
Perth Amboy, N. J. (5 ft. Above Bottom)	0	19	19	1	10	11
Red River, North:						
Grand Forks, N. Dak	105	63	168	5	0	5
Red River, South:						
Denison, Tex	1	43	44	0	2	2
Index, Ark	64	41	105	7	0	7
Bossier City, La	19	20	39	2	2	4
Alexandria, La	77	22	99	18	1	19
Rio Grande River:						
Alamosa, Colo	36	71	107	0	2	2
El Paso, Tex	25	22	47	3	2	5
Laredo, Tex	238	27	265	29	4	33
Brownsville, Tex	4	207	211	0	1	1
Roanoke River:						
John H. Kerr Resr/ Dam, Va	9	10	19	0	0	0
Sabine River:						
Ruliff, Tex	16	24	40	1	1	2
Sacramento River:						
Greens Landing, Calif	0	4	4	0	0	0
St. Lawrence River:						
Massena, N. Y	4	14	18	0	0	0
San Joaquin River:						
Vernalis, Calif	8	24	32	1	7	8
San Juan River:						
Shiprock, N. Mex	129	38	167	14	13	27
Savannah River:						
North Augusta, S. C	29	17	46	2	0	2
Port Wentworth, Ga	9	15	24	<1	0	<1
Schuylkill River:						
Philadelphia, Pa	6	8	14	1	0	1
Shenandoah River:						
Berryville, Va	3	11	14	0	0	0
Ship Creek:						
Anchorage, Alaska	0	6	6	0	0	0
Snake River:						
Ice Harbor Dam, Wash	6	11	17	1	1	2
Wawawai, Wash	3	9	12	0	1	1
Payette, Idaho	20	16	36	3	4	7
South Platte River:						
Julesburg, Colo	10	77	87	1	56	57
Spokane River:						
Post Falls Dam, Idaho	2	7	9	0	0	0
Susquehanna River:						
Sayre, Pa	3	6	9	0	0	0
Conowingo, Md	4	6	10	1	0	1
Tennessee River:						
Lenoir City, Tenn	7	10	17	0	0	0
Chattanooga, Tenn	31	22	53	1	0	1
Bridgeport, Ala	10	11	21	1	0	1
Pickwick Landing, Tenn	9	16	25	1	0	1
Tombigbee River:						
Columbus, Miss	27	22	49	1	0	1
Truckee River:						
Farad, Calif	3	6	9	0	0	0
Verdigris River:						
Nowata, Okla	89	37	126	7	0	7
Wabash River:						
New Harmony, Ind	51	28	79	5	0	5
Willamette River:						
Portland, Ore	1	3	4	0	0	0
Yakima River:						
Richland, Wash	1	6	7	0	1	1
Yellowstone River:						
Sidney, Mont	108	22	130	17	4	21
Maximum	296	692	854	38	56	58
Minimum	0	1	3	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (7).

TABLE 2.—QUARTERLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN SURFACE WATERS, APRIL 1963–MARCH 1964

[Concentrations in pc/liter]

Station	Apr.–June 1963	July–Sept. 1963	Oct.–Dec. 1963	Jan.–Mar. 1964
Allegheny River:				
Pittsburgh, Pa	1.8	[a]—	2.8	—
Animas River:				
Cedar Hill, N. Mex	—	1.8	—	1.7
Apalachicola River:				
Chattahoochee, Fla	—	2.9	—	1.5
Arkansas River:				
Coolidge, Kans	—	6.6	—	0.9
Ponca City, Okla	5.9	6.5	4.4	—
Fort Smith, Ark	—	6.7	—	3.5
Little Rock, Ark	—	4.8	4.4	—
Pendleton Ferry, Ark	5.5	—	4.3	—
Bear River:				
Preston, Idaho	—	3.7	—	1.1
Big Horn River:				
Hardin, Mont	5.8	—	2.3	—
Big Sioux River:				
Sioux Falls, S. Dak	—	9.5	5.0	2.8
Chattahoochee River:				
Atlanta, Ga	1.6	—	1.7	—
Columbus, Ga	1.5	—	1.7	—
Lanett, Ala	—	2.0	—	1.7
Chena Slough:				
Fairbanks, Alaska	0.7	—	0.2	—
Clearwater River:				
Lewiston, Idaho	—	1.2	—	0.8
Clinch River:				
Clinton, Tenn	—	1.4	—	2.0
Kingston, Tenn	5.6	9.4	6.5	7.5
Colorado River:				
Loma, Colo	2.5	—	1.4	—
Page, Ariz	—	4.2	—	5.9
Boulder City, Nev	1.8	—	1.5	—
Parker Dam, Calif-Ariz	—	1.0	—	1.9
Yuma, Ariz	0.9	—	1.1	—
Columbia River:				
Northport, Wash	—	3.4	—	1.5
Wenatchee, Wash	1.1	—	2.8	—
Pasco, Wash	2.4	2.7	3.4	3.1
McNary Dam, Ore	1.1	2.6	2.5	2.2
Bonneville, Ore	—	1.2	—	2.0
Clatskanie, Ore	1.3	2.5	1.6	—
Connecticut River:				
Wilder, Vt	—	2.6	—	1.3
Northfield, Mass	1.4	3.1	1.8	—
Enfield Dam, Conn	—	2.5	—	1.7
Cumberland River:				
Clarksville, Tenn	—	2.0	—	—
Cuyahoga River:				
Cleveland, Ohio	—	5.3	—	4.3
Delaware River:				
Martins Creek, Pa	1.7	—	1.6	—
Trenton, N. J	—	3.1	—	1.8
Philadelphia, Pa	1.1	—	2.1	—
Escambia River:				
Century, Fla	1.4	—	1.2	—
Great Lakes:				
Duluth, Minn	0.4	—	0.7	—
Sault Ste. Marie, Mich	—	1.5	—	0.8
Milwaukee, Wisc	0.8	—	0.8	—
Gary, Ind	—	1.6	—	1.2
Port Huron, Mich	1.3	—	1.2	—
Detroit, Mich	—	2.4	—	1.4
Buffalo, N. Y	2.2	—	2.5	—
Green River:				
Dutch John, Utah	—	2.7	—	4.6
Hudson River:				
Poughkeepsie, N. Y	3.8	—	5.0	—
Illinois River:				
Peoria, Ill	3.5	—	2.3	—
Grafton, Ill	—	4.4	—	3.8
Kanawha River:				
Winfield Dam, W. Va	—	2.9	—	1.1
Kansas River:				
De Soto, Kans	4.9	7.4	5.2	—
Klamath River:				
Keno, Ore	1.4	—	1.8	—
Little Miami River:				
Cincinnati, Ohio	—	5.3	1.4	3.3
Maumee River:				
Toledo, Ohio	4.9	—	2.7	—
Merrimack River:				
Lowell, Mass	—	1.6	—	1.8
Mississippi River:				
St. Paul, Minn	—	7.2	4.3	3.2
Dubuque, Iowa	4.2	—	3.7	—
Burlington, Iowa	—	7.3	4.3	2.8
E. St. Louis, Ill	4.0	—	3.8	—
Cape Girardeau, Mo	—	5.3	—	2.9
W. Memphis, Ark	3.6	—	3.6	—
Vicksburg, Miss	—	4.2	—	2.7
Delta, La	3.3	—	3.4	—
New Orleans, La	—	4.5	—	2.8
Missouri River:				
Williston, N. Dak	2.5	—	2.8	—
Bismarck, N. Dak	—	3.5	—	3.9
Yankton, S. Dak	3.3	—	3.3	—
Omaha, Nebr	—	4.5	—	3.3
St. Joseph, Mo	6.2	—	3.4	—
Kansas City, Kans	—	5.0	—	2.9
Missouri City, Mo	4.1	—	4.1	—
St. Louis, Mo	—	6.2	—	3.1
Monongahela River:				
Pittsburgh, Pa	2.7	3.3	3.3	—
North Platte River:				
Henry, Nebr	2.5	—	0.7	—
Ohio River:				
Toronto, Ohio	—	4.9	2.8	—
Addison, Ohio	—	4.0	—	2.2
Huntington, W. Va	1.9	—	3.0	—
Cincinnati, Ohio	—	3.7	—	1.6
Louisville, Ky	2.3	3.6	4.0	—
Evansville, Ind	—	4.2	—	2.5
Cairo, Ill	2.9	—	2.8	—
Ouachita River:				
Bastrop, La	—	4.5	—	3.0
Pend Oreille River:				
Albeni Falls Dam, Idaho	0.9	—	1.3	—
Platte River:				
Plattsmouth, Nebr	—	5.2	—	2.1
Potomac River:				
Williamsport, Md	1.4	—	1.7	—
Great Falls, Md	—	2.5	—	1.4
Washington, D. C	—	3.4	—	1.2
Rainy River:				
Baudette, Minn	2.5	4.7	4.1	—
International Falls, Minn	2.9	4.3	3.8	—
Red River, North:				
Grand Forks, N. Dak	—	11.3	7.1	4.9
Red River, South:				
Denison, Tex	—	5.6	—	5.8
Index, Ark	5.3	4.9	4.3	—
Bossier City, La	—	5.0	—	4.4
Alexandria, La	4.0	—	4.1	—
Rio Grande River:				
Alamosa, Colo	1.1	—	0.8	—
El Paso, Tex	—	1.9	—	0.6
Laredo, Tex	3.7	—	2.4	—
Brownsville, Tex	—	2.3	—	2.6
Roanoke River:				
John H. Kerr Resr/Dam, Va	1.3	—	2.6	—
Sabine River:				
Ruliff, Tex	—	3.2	—	2.5
Sacramento River:				
Courtland, Calif	—	1.4	1.0	1.0
St. Lawrence River:				
Massena, N. Y	—	2.3	—	1.6
San Joaquin River:				
Vernalis, Calif	1.3	—	1.5	—
San Juan River:				
Shiprock, N. Mex	1.9	—	2.1	—
Savannah River				
North Augusta, So. Car	—	2.1	—	1.7
Port Wentworth, Ga	2.2	3.2	2.4	1.7
Schuylkill River:				
Philadelphia, Pa	—	3.7	—	1.4
Shenandoah River:				
Berryville, Va	1.2	—	1.0	—
Ship Creek:				
Anchorage, Alaska	—	0.9	—	0.4
Snake River:				
Ice Harbor Dam, Wash	—	1.3	—	1.0
Wawawai, Wash	0.9	—	0.7	—
Payette, Idaho	1.5	—	0.8	—
South Platte River:				
Julesburg, Colo	1.7	—	1.8	—
Spokane River:				
Post Falls, Idaho	—	1.2	—	1.3
Susquehanna River:				
Sayre, Pa	—	2.3	—	1.3
Conowingo, Md	1.6	—	3.0	—
Tennessee River:				
Lenoir City, Tenn	1.5	—	2.1	—
Chattanooga, Tenn	1.7	3.3	2.2	2.0
Bridgeport, Ala	1.6	—	2.2	—
Pickwick Landing, Tenn	—	2.5	—	2.1
Tombigbee River:				
Columbus, Miss	—	3.6	—	3.1
Truckee River:				
Farad, Calif	1.0	—	1.0	—
Verdigris River:				
Nowata, Okla	4.2	—	6.0	—
Wabash River:				
New Harmony, Ind	3.1	—	2.5	—
Willamette River:				
Portland, Ore	0.7	—	0.5	—
Yakima River:				
Richland, Wash	—	1.0	—	0.3
Yellowstone River:				
Sindey, Mont	—	5.0	—	1.9
Maximum	6.2	11.3	7.1	7.5
Minimum	0.4	0.9	0.2	0.3

[a] Dash indicates no sample collected.

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (7).

Strontium–90 Determinations and Results

Beginning in 1959, strontium–90 analyses of the total solids of surface waters were made quarterly on three-month composites of aliquots from weekly samples. Beginning in November 1962, the frequency of analysis was reduced to two quarterly samples per year at each sampling point except those stations immediately below nuclear installations, where quarterly analyses were continued. The method used for determining strontium–90 is a modification of a procedure described by Harley (*10*). The yttrium–90 together with an yttrium carrier is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Table 2 presents the results of quarterly analyses of strontium–90 concentrations in U. S. surface waters for January–March 1964 as well as results for the previous three quarters for comparative purposes. The stations are arranged in the table according to their relative locations on the river, the first station being closest to the head-waters.

Floyd and Weaver summarized the strontium–90 results obtained from 1959 through 1963 in the August 1964 issue of *RHD* (*11*). During the January-March 1964 quarter, strontium–90 concentrations remained at about the same levels as were observed in the previous quarter. The average for the first quarter 1964 was 2.4 pc/liter, with values ranging from 0.3 to 7.5 pc/liter. While there are no standards for strontium–90 activity of total solids in surface water, the Public Health Service Drinking Water standards set the limit for strontium–90 concentrations in drinking water at 10 pc/liter (*12*). This limit for public water supplies is greater than the highest level observed during January-March 1964.

Discussion

The monthly dissolved beta activity averages exceeded 100 pc/liter only on the Columbia River and the Rio Grande. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 170 and 854 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, ranges in the monthly averages to 38 pc/liter. Of all stations, six on different rivers had monthly average dissolved alpha activity greater than 10 pc/liter.

While there are no generally applicable standards for surface waters, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*13*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*12*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663, 1958 Edition*, Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402. Price $1.50.
(*2*) *Ibid.*, 1959 Edition. Price $1.75.
(*3*) *Ibid.*, 1960 Edition.[2]
(*4*) *Ibid.*, 1961 Edition.[2]
(*5*) *Ibid.*, 1962 Edition.[2]
(*6*) *Ibid.*, 1963 Edition (in press).
(*7*) *Ibid.*, 1964 Edition (to be published).
(*8*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).
(*9*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data*, *4*: 306–16, (June 1963).

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium–90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

(*10*) Harley, J. H.: Radiochemical Determinations of Strontium–90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, HASL, U. S. Atomic Energy Commission, New York Operations Office (1962).

(*11*) Division of Water Supply and Pollution Control, Public Health Service: Radioactivity in Surface Waters of the United States, February 1964, *Radiological Health Data, 5:* 383–86 (August 1964).

(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

(*13*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association, 53:* 704 (June 1961).

Section IV—Other Data

PROGRESS IN DENTAL RADIOLOGICAL HEALTH

James W. Miller[1]

Medical and dental uses of radiation are the principal sources of man-made ionizing radiation to which the population of the United States is exposed. Diagnostic X-ray procedures account for almost all exposure from these sources (*1*). A review of the literature shows that prior to 1960 approximately 75 percent of the dental X-ray units in this country would not meet recommended standards; the major X-ray machine defects were unnecessarily large beams and insufficient filtration.

Of the more than 200,000 X-ray machines in use in this country, approximately 100,000 are owned and operated by dentists, exposing about 185,000,000 dental films a year. According to the U. S. National Health Survey, 49 million visits were made for dental X-rays during a 12-month period starting in July 1960 (*2*). On the average, an X-ray procedure was performed once in every five dental visits.

Since the major part of patient exposure in dentistry is from intra-oral roentgenography, many studies have been reported on the dose delivered (*3–14*). The values reported have usually been "air dose" measured at the tip of the cone, or "skin dose", that which strikes the patient's face. The "air dose" from a full-mouth survey of 14 films ranged from five roentgens to 315 roentgens, and the reported range of "skin dose" ranged from 1.5 roentgens to over 75 roentgens.

Patient gonadal dose incidental to intra-oral roentgenography depends on tube angulation, torso length, kilovoltage and beam diameter. Estimates of measured relative gonadal dose in adult males from dental X-ray procedures vary from 1/1000 to 1/10,000 of the "air dose" (*15–17*). Secondary and/or scattered radiation from the pointer cone, filter and patient's face has been shown to be the principal source of radiation to the reproductive organs from dental X-rays (*18*).

Reports of dermatitis and ulceration on the hands of dentists resulting from the practice of holding dental films in place during roentgenographic procedures have appeared in the literature. Young and Kunkel (*19*), reporting on 52 dentists who had developed X-ray dermatitis of the hands as a result of holding films, noted that 31 percent of these dentists, ranging in age from 34 to 66 (with an average age of 52), experienced malignant degeneration of such lesions. In a sample survey (*20*), the American Dental Association received a 9.5 percent affirmative reply to the question "Do you ever hold the film in the patient's mouth while the X-ray is being taken?" Another question in the survey was "Have you ever developed an X-ray burn on your fingers?", to which a total of 1.7 percent replied in the affirmative. No dentist under 30 years of age reported having had X-ray burns, but nearly 5 percent of dentists over 60 years of age admitted having had X-ray burns. Those with such burns had used dental roentgenographic equipment for an average of 14 years.

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Investigators have also reported large numbers of dental X-ray units which were operated in an unsafe manner, thereby subjecting dentists and ancillary personnel to unnecessary levels of exposure (*21–23*). Other studies, conducted in larger centers of population by interested parties and agencies following the 1956 report of the National Academy of Science, indicated that a large percentage of the dental X-ray machines in this country did not meet recommendations set forth by the National Committee on Radiation Protection and Measurements (*24*) or the recommendations of the American Academy of Oral Roentgenology (*25*).

Until about 1956, most of the radiation protection recommendations were made to protect occupationally exposed persons. Since that time, however, the need to control radiation exposure of the public has been widely emphasized. This awareness is evidenced by the rapidly expanding activities of the Division of Radiological Health, established in 1958 within the Public Health Service; the Federal Radiation Council, which was formed in 1959 to provide a Federal policy on human radiation exposure; and the enactment of specific legislation for radiation control activities by State and Federal agencies. The bulk of this legislative action for radiation control has taken place within the past four years. Because of legislative action and emphasis on this public health problem, most States are developing comprehensive radiation control programs.

Growth of Dental X-Ray Control Programs

A comprehensive radiological health program encompasses four principal areas: inspection, correction, education and research. Each is an integral part of a plan to attain the ultimate objective of eliminating unnecessary radiation exposure from dental sources.

Recognizing the need to provide assistance to health agencies in the planning, developing, and operating stages of their dental activities, the Division of Radiological Health in 1959 established the Dental X-Ray Program in its State Assistance Branch. This unit was assigned the responsibility of providing consultation, information, and other technical services to State and local health agencies in the development of sound dental radiological health programs. The objectives of this unit were to assist in the establishment of dental radiological health programs in all States and territories. The programs now in progress stress reduction of unnecessary exposure to patient and operator while attaining superior diagnostic quality of dental radiographs. Advice and assistance has been provided to health officers and State dental associations throughout the country, and thousands of Dental "Surpak" surveys have been made in most States.

Dental Surpak Surveys

Two survey techniques for the inspection of dental X-ray equipment are in general use. One method developed by the Public Health Service for conducting a large scale survey of dental X-ray machines is the "by mail" dental Surpak procedure, designed to assess the size of the beam at the end of the pointer cone, the approximate roentgen output, total filtration (inherent and added), beam symmetry, and leakage radiation in the direction of a patient's face. While this procedure assists materially in indicating the need for reducing patient and occupational exposure, it does not completely remove the need for installation inspections. The Surpak does serve, however, as an aid in surveying rural and inaccessible areas, locating and identifying machines needing priority attention, and as a method of followup after recommended improvements reportedly have been made.

A total of 58,000 Surpaks have been distributed by the Division of Radiological Health to 39 States as of June 30, 1964. Of the States that have used the Surpak, 27 have completed their initial survey in the sense that 65 to 95 percent of the dentists participated on a voluntary basis. Nationally, the mode is 80 percent voluntary participation. Results from 40,810 Surpaks returned by December 30, 1963 provided the beam diameter information in table 1. In an attempt to assess the progress in dental radiological health, the data were compiled by calendar year starting with 1960, the first year the Surpak was used in State programs.

Although results from different parts of the country varied by as much as 15 percent when the information was combined, a trend could be

letected in the increase in the number of dental X-ray machines meeting present recommended standards. This trend is apparent in table 1.

TABLE 1.—BEAM DIAMETERS OF X-RAY MACHINES

[Percent]

Beam diameter (inches)	1960	1961	1962	1963
-3.00	45.2	56.4	59.9	63.6
.01 up	53.6	41.8	39.1	35.4
Unknown	1.2	1.8	1.0	1.0
Totals	100.0	100.0	100.0	100.0

Recommendations of the Public Health Service currently suggest that the beam diameter should be 2.75 inches at the tip of the cone regardless of length and shall not be greater than three inches. Using three inches as the maximum beam size, the proportion of machines not meeting this requirement dropped from 53.6 percent in 1960 to 35.4 percent for the year 1963, reflecting a substantial decrease in the dental contribution to radiation exposure.

Recommendations for total filtration of the useful beam are 1.5 mm. of aluminum equivalent for equipment capable of operating up to and including 70 kvp and 2.5 mm. total for those operating above 70 kvp. Even though the accuracy of the filtration determination by the surpak method is subject to some inherent errors, sufficient information is obtained to make a reasonable estimate in most cases. The unknown values in table 2 are the results of over-or underexposure of the surpak films, making it impossible to estimate the total filtration. Using 1.5 mm. of aluminum as the minimum amount of filtration required for dental X-ray machines regardless of kvp, we note an increase of 18 percent from 1960 to 1963 in number of machines meeting this minimum standard.

TABLE 2.—SURPAK RESULTS OF TOTAL FILTRATION

[Percent]

Filtration	1960	1961	1962	1963
<1.5	51.9	38.2	29.7	29.0
≥1.5	42.2	46.2	55.4	60.2
Unknown	5.9	15.6	14.9	10.8
Totals	100.0	100.0	100.0	100.0

By 1962, several States had progressed to a point in their program where the original Surpak data had been evaluated, and recommendations for correction were sent to the dentists. In most cases, the State health department sent corrective devices supplied by the Public Health Service to the dentist to bring the X-ray machine into compliance with established standards for filtration and collimation. After a period of time, a follow-up Surpak was sent to the dentist to determine whether the lead collimator and aluminum filters had been properly placed in the machine.

As a result of this type of follow-up program, 85.5 percent of the dental X-ray machines found to be below recommended standards for beam diameter at the time of the original survey were brought into compliance. Similar results were obtained in 1963. An 80-percent compliance from owners of X-ray machines originally found to be below standards has been achieved to date by this dental mail-order survey and correction method.

Physical Surveys

Another method of conducting a survey of dental X-ray machines is physical inspection of dental offices. The physical survey usually covers equipment, technique and occupational exposure. The method of inspection will vary with the established objectives of the X-ray program. There are, of course, many advantages to this type of survey. Defects in equipment can usually be corrected at the time of inspection. Another great advantage is the opportunity it provides for face-to-face education which often is very effective in accomplishing program objectives.

Of the 50 States that have instituted some type of inspection program, 11 conduct installation visits only; six use the Surpak only; and 33 States have or are using a combination of the Surpak with some other method, usually an installation inspection. The estimated number of dental X-ray machines surveyed by State or local health departments is conservatively set at 70,000. Although more inspections have been conducted, many have been duplications on the same dental X-ray machine.

At this time, the results of over 10,000 physical surveys of dental installations have been tabulated. The data regarding collimation and total filtration from these physical surveys, when compared with results of Surpak method, show a very close correlation in percentage meeting recommended standards at the time of the survey. After the survey, in a partial tabulation of results to date, 98 percent of the X-ray machines met the recommended standards for filtration, and 96 percent met the collimation requirement. Areas which will require additional attention, brought out by these surveys, are related to the techniques employed by the dentists. Further reduction of patient and operator exposure can be accomplished by using the fastest film available, although some changes of equipment and/or techniques are necessary to utilize this film. Strict attention to exposure time, development time, and temperature must be followed.

Scope of State Dental X-Ray Programs

Although every State has not been able to develop a comprehensive program up to this time, programs of inspection and correction of dental X-ray equipment and/or installations have been or are now being conducted in each of the 50 States. The majority of these inspection programs have been conducted on a voluntary rather than a regulatory basis. While regulations may be in effect, most health departments prefer to conduct cooperative voluntary programs with the dental profession.

Figure 1 shows the growth of State dental radiological health activities. As can be seen most program activity was noted between the years 1960 and 1964. The scope of these programs include a survey of the X-ray equipment with correction of existing defects and, where indicated, recommendation of changes in technique to further reduce radiation exposure.

These surveys also indicate that there is still a sizable amount of exposure (not necessary for the production of good diagnostic X-rays) that should be eliminated.

In a recent attempt to evaluate dental radiological health programs, information was obtained on the planned scope of the State's programs. This was separated into four categories, as presented in table 3. From this breakdown, it appears that many States have plans for a continuing program of inspection and correction.

TABLE 3.—PLANNED SCOPE OF STATE PROGRAMS [a]

Scope	Number of States [b]
Unknown	5
Inspection only	5
Inspection plus correction	15
Periodic inspection and correction	10
Continuous program of inspection, correction and education	17

[a] Data from 1962 status report (*26*).
[b] Includes Puerto Rico and District of Columbia.

It is generally agreed that a certain degree of educational effort will be necessary to obtain the ultimate objective of dental radiological health. This is especially true of those States whose programs have been on a voluntary, cooperative basis with the dental profession and in others on which only the condition of the equipment can be regulated.

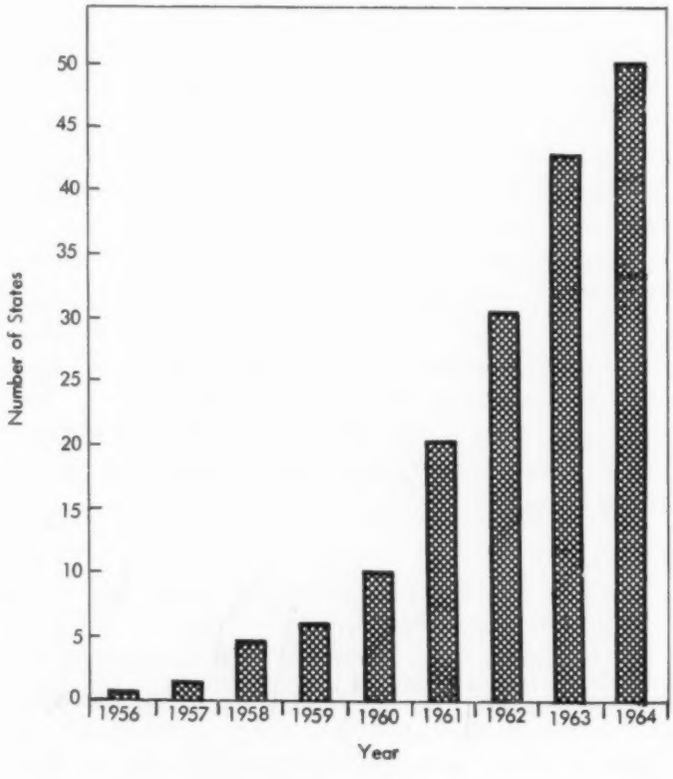

FIGURE 1.—STATES PARTICIPATING IN DENTAL RADIOLOGICAL HEALTH ACTIVITIES

In 1962, 34 States reported that they had already provided educational materials and programs on radiological health to the dental profession. Five other States indicated they were planning such programs. The long-range effectiveness of these educational efforts to date is difficult to assess. One method of evaluation might be the number of dental X-ray machines found in need of filtration or collimation. Based on such a method or on other survey findings, educational efforts employed by health agencies to date have not been too effective.

Ample information exists, however, which, if put into use, would enable a dental radiological health program to advance reasonably close to its ultimate objective of reducing radiation exposure to the minimum, consistent with good diagnostic radiography. The intensive inspection and correction programs putting into effect what is already known about X-ray equipment defects has been significantly successful in achieving modification of equipment to meet current recommended standards. Knowledge also exists on techniques which will further reduce patient and operator exposure from diagnostic radiography. It appears that future activities by health agencies must be directed to provide the dental profession with this specific knowledge about radiation and techniques which can further reduce exposure. This solution agrees with a statement by Scott (*27*) that ". . . the key to implementing the safe use and control of medical radiation lies in the education of all practicing physicians in the fundamentals of genetics, radiobiology and radiology." Many State health agencies have progressed to the point where their dental inspection and correction programs are limited to new installations and to a projected resurvey every two to five years. Now is the time to expand these programs and work with the universities and the profession by providing the undergraduate and the practicing dentist with the changing concepts and new knowledge in dental radiology.

Summary

Inspection and correction programs of dental X-ray equipment and/or installations have been or are now being conducted in each of the 50 States.

Division of Radiological Health Surpak surveys of over 40,000 dental X-ray machines revealed that those meeting recommended standards for a beam diameter of three inches or less rose from 45.2 percent in 1960 to 64 percent in 1963. The percentage of those machines with 1.5 mm. or more of total aluminum filtration increased from 42.2 percent in 1960 to 60.2 percent in 1963.

Surveys also indicate that there is still a sizable potential for exposure reduction through the adoption of improved techniques that will not jeopardize the production of good diagnostic X-rays.

Correction of filtration and collimation defects have resulted in a substantial radiation decrease in the dental contribution to population exposure. However, educational means will be necessary to attain the ultimate objective of eliminating unnecessary radiation exposure.

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UTAH DENTAL X-RAY MACHINE SURVEY, 1961-1963

John B. Wheeler and Grant S. Winn [1]

As a part of Utah's program to eliminate unnecessary radiation exposure to all people involved directly or indirectly with X radiation, dental machines in the State were surveyed in 1961 by the dental Surpak survey method (*1*) and were resurveyed in 1962-63 by physical inspection at which time simple filtration and collimation defects were corrected by the surveyors. By the middle of February 1963, 432 dental installations with 455 X-ray machines were surveyed. The information obtained from these installations is the basis of this report. Several more have been surveyed since the compilation of the data. Three main areas were inspected during the physical survey: the X-ray machine itself; the exposing and developing of the film; and the exposure to personnel and patient. The present report summarizes the results of the 1962-63 physical survey and, where possible, attempts to draw comparisons with the 1961 Dental Surpak Survey.

Survey Procedures

Each machine was checked for: filtration, by noting the added filtration and using the inherent filtration listed by the manufacturer; collimation, with a fluorescent screen; roentgen output, using a Victoreen r-meter both before and after filtration was added; and other important factors including cord length, timer control, pointer cone, and tube head stability. The operational questions included the number of films per week, average exposure time, kvp and ma used, protective barriers and lead aprons for personnel and patients, personnel monitoring, type of film and developer, developing time and developer temperature. The third area of inspection was the operating position of the dentist and/or assistant. A water-filled plastic bottle, 5 inches in diameter and 8 inches tall, was used as a phantom to scatter the radiation in a manner similar to a patient's head. Measurements with a CS–40A "Cutie Pie" survey meter were taken where the X-ray personnel stood for right and left bitewing exposures and the anterior upper periapical exposure. Whenever it was felt that the exposure rate was higher than necessary or could be reduced, measurements were taken in new positions to find the lowest possible rate. The operators were informed of these new positions verbally. Individual letters summarizing all recommendations made during the survey were sent to each dentist after the survey.

Physical Characteristics of X-ray Machines

Filtration: The Public Health Service recommendations (*2*) for filtration were used on the survey. Two mm of aluminum equivalent filtration are suggested for dental machines operating at 70 kvp and less, and 2.5 mm for machines operating over 70 kvp. The inherent filtration of the X-ray machines was determined from the PHS information sheet entitled, "Dental X-ray Units—General Information" (*3*). Of all the X-ray machines surveyed, not including three cephalographic machines, 47 percent had their filtration deficiencies corrected during the survey. Two percent more

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needed corrections, but could not be corrected because either the pointer cone could not be removed or a special size filter was needed. The average addition was 0.9 mm of aluminum. Close to 52 percent of the 70 kvp machines and only 30 percent of the 90 kvp machines needed more filtration. This difference is probably due to the recent manufacture of the 90 kvp machines and the corresponding impact of Handbook 76 (*4*) on manufacturing design. The Surpak results showed that 23 percent of the 346 machines surveyed had two millimeters or more of filtration. The corresponding figures for the physical survey are 55 percent before modification and 98 percent after modification (see figure 1). The increased percentage of machines with 2 or more mm of filtration between the Surpak survey and the physical survey (32 percent) indicates that many dentists had their machines corrected after learning of their deficiencies from the State Health Department. The figure of 2 mm or more is used as a basis for comparison since there are no complete figures indicating the relationship between amount of filtration and the kvp in the Surpak results.

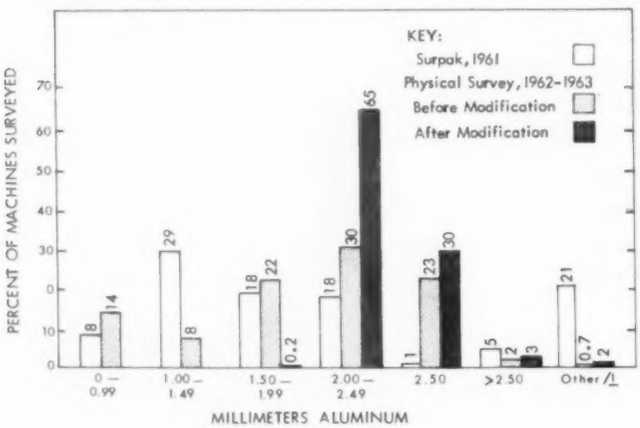

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FIGURE 1.—FILTRATION DISTRIBUTION

Collimation: The recommended X-ray beam diameter (*2*) of 2.75 inches was used as a goal for the survey. The lead collimators supplied by the Public Health Service for the most common dental machines were designed to give a beam diameter of 2.75 inches at the end of the pointer cone. Collimators were added to 20 percent of the machines during the survey (see figure 2). Only 1 percent more needed corrections which the surveyors were unable to make

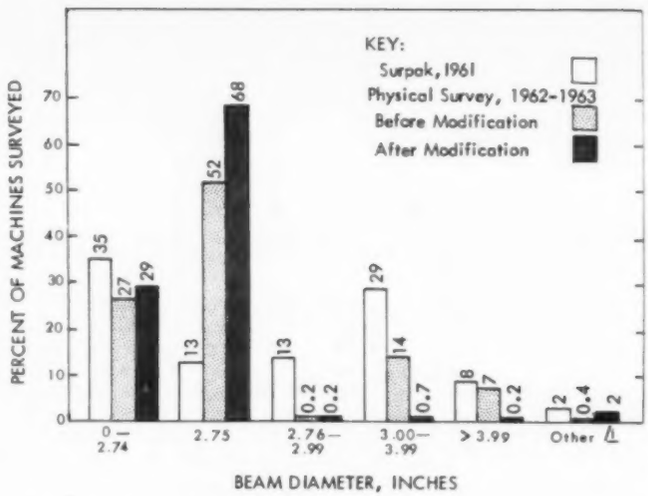

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FIGURE 2.—BEAM DIAMETER DISTRIBUTION

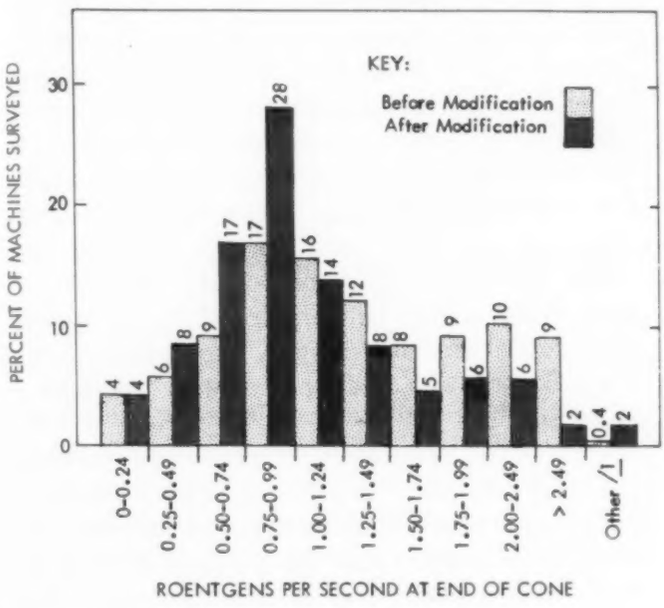
because they could not remove the pointer cone or did not have the proper size collimator. In many cases collimators were fabricated at the time of the survey or were placed in such a way as to correct the beam size of the machines for which there were no precut collimators. Less than 1 percent of the machines were left with beam diameters between 2.75 and 3.00 inches. They were left unchanged since they could not be corrected by the surveyors and caused very little excess exposure to the patients. The average beam size of those machines needing collimation was 3.7 inches (almost one inch too large), resulting in an area 80 percent larger than that of the recommended 2.75-inch beam. Thus, before modification, a total of 22 percent of the machines had beam diameters greater than 2.75 inches. Approximately 1 percent, although they had beams of 2.75 inches or less, were off-center. Additional filtration as well as collimation was needed in 15 percent of all the machines.

The value of the Surpak survey is apparent from the improvements noted between the times of the surveys. While 48 percent of the machines surveyed by the Surpak method had beam diameters of 2.75 inches or less, 78 percent of the machines checked in the subsequent physical survey conformed to this standard.

Roentgen Output: The reduction in roentgen output per second at the end of the pointer cone, due to the filtration added during the survey, may be seen from table 1 and figure 3.

ABLE 1.—EFFECT OF FILTRATION ADDED DUR-NG PHYSICAL SURVEY ON ROENTGEN OUTPUT

Output (r/sec)	Percent of machines surveyed	
	Before added filtration	After added filtration
s than 0.75	19	30
75–0.99	17	28
or more	64	42



/1 Unknown or could not be determined

FIGURE 3.—ROENTGEN OUTPUT DISTRIBUTION

Kilovoltage and Milliamperage: Of the machines surveyed, 76 percent were designed to operate around 70 kvp or less, while 24 percent were 90 kvp machines. In a few cases, the operators operated at about 70 kvp settings with 90 kvp machines. The most common milliamperages used were 10 ma (72 percent), and 15 ma (19 percent). Most variations from these milliamperages were minor.

Film Exposure and Development

Exposure Timer: Fifty-one percent of the X-ray machines had mechanical timers, while 49 percent had electrical timers. This percentage of mechanical timers is expected to decrease with time as more new machines replace the older ones, and electronic timers are substituted for the mechanical timers.

X-Ray Films: The grouping of the X-ray films used was done according to relative speed (*5*). The American Standards Association groups the film speeds into groups "A" through "F," with "F" being the fastest. Each film type is designated by the reciprocal of the exposure in roentgens required to produce a density of 1.0 under set conditions. Thus, low speed films have low numbers and the fast speed films have high numbers (*6*). From table 2, it can be seen that 43 percent of the operators used "B" speed group films and 55 percent used "C" or "D" films. The decrease in radiation exposure when going from group "B" to group "D" can be up to eight-fold. Therefore, the highest speed films should be used whenever possible in order to reduce unnecessary exposure to patients and personnel.

TABLE 2.—FILM SPEED DISTRIBUTION [a]

Speed group	Speed range (reciprocal roentgens)	Percent using film	Common films in group
A	1.5– 3.0	0.4	Rinn DC
B	3.0– 6.0	43	DuPont "D", Kodak Radia-tized, IFI BH 1, Rinn M.F.
C	6.0–12.0	15	IFI SDH 1, Minimax Intermediate, Rinn E.F.
D	12.0–24.0	40	DuPont "LF", Kodak Ultra-Speed, Minimax Extra Fast, Rinn S.F.
E	24.0–48.0	0	Rinn H.F.
F	48.0–96.0	0	None
—	Unknown	1.5	

[a] Film characteristics from reference (*5*).

Darkroom Procedure: In many installations, the darkroom procedure left much to be desired. The surveyors found that the dentists usually had their assistants develop the films. Generally the assistants had had no training in proper developing techniques, but had received a few comments or instructions from the dentist or previous assistants on the overall procedure. The most common mistake was a long exposure time and a short development time—"to save time." This procedure greatly increases the radiation exposure to the patient and personnel while saving only two or three minutes. It is felt that in most cases, the dentist could be continuing his examination or work on the patient during the lengthened developing period with no waste of time or inconvenience to him or the patient.

Two-thirds (66 percent) of the installations used thermometers in the developer, 3 percent had thermometers but did not use them, and 31 percent had no thermometer. Table 3 lists the reported usual temperature of the developer.

It is assumed that the developing solutions reported to be at room temperatures were in the 65°-75° F. range. Therefore, 97 percent were in the 65°-75° F. range.

TABLE 3.—DEVELOPING TEMPERATURES USED (° F)

	60–64	65–67	68	69–75	Room temperature	76–78
Number	8	26	166	101	150	4
Percent	2	6	36	22	33	1

When considering the development time distribution, it should be noted that many of those interviewed merely estimated the time, since they used the "sight" method instead of a timer. This involves checking the film by sight against a red light during development to obtain the best picture, which often leads to overexposure and under-development. The film and developer solution manufacturers recommend 3.5 minutes as the minimum and 5 minutes as the optimum time for the film to be in the developer when its temperature is 68° F. However, 54 percent of the installations reported less than 3.5 minutes, 35 percent more than 3.5 minutes, and 11 percent used the sight method, which is generally shorter than 3.5 minutes. It should be noted that more than half of the installations did not use 68° F., and therefore should have used a different developing time. It appears evident that most of the installations did not use the optimum time, and many used less than the minimum recommended time.

Less than half (45 percent) completely changed the developer every 4 weeks or less, 61 percent changed every 6 weeks or less and 2 percent changed the solution after 20 weeks or more. The longest period between changes was 6 months. However, many replenished the solution between changes. There were 20 percent who changed solutions only when the films were not developing properly or the solution had evaporated and oxidized. Many of those giving the number of weeks between changes were averaging or guessing in that they changed solutions when the quality of the films necessitated, rather than on a fixed schedule. Only 39 percent of the darkrooms were light tight; that is, no outside light could be seen in the darkroom.

Exposure to Patients and Personnel

The reduction of radiation exposure to the operating personnel as well as the patients was of primary importance in the survey. To obtain exposure figures on operating personnel, readings were taken at normal operating positions and at other possible operating positions until one of minimal exposure was found. Also, the presence of protective barriers, lead aprons for patient and operator, personnel monitoring, exposure per film, and length of timer cord were noted. Of the timer cords used, 78 percent were 6 feet or longer while 22 percent were less than 6 feet long. Often a cord shorter than 6 feet was adequate in the presence of shielding.

Personnel Monitoring: Personnel monitoring was not used in any form by 57 percent, 8 percent used film badges, 1 percent used pocket dosimeters and 34 percent used dental films with a paper clip or coin attached. Thus, 43 percent of the dentists had used, or were using, some sort of personnel monitoring while in their present offices. The 9 percent who used film badges or pocket dosimeters always registered below 25 milliroentgens per week. Sometimes a slight image had been found on dental film badges, but these were considered inconclusive since the film had often been used for several weeks at a time and had been placed in the X-ray room, rather than on the personnel. After considering the personnel monitoring results, the maximum exposure rate of personnel (see below), and the workloads found in this survey, it would appear that there is little reason for careful personnel monitoring (see Handbook 76 (4)), except in the cases where the operator holds films, stands next to the patient, has a large workload, or wants to be sure he is getting very little exposure.

Number of Films Per Week: Of the dentists involved with the X-ray machines surveyed, 63 percent used less than 50 films (exposures) per week per machine (see figure 4). The qualification of number of films per machine should

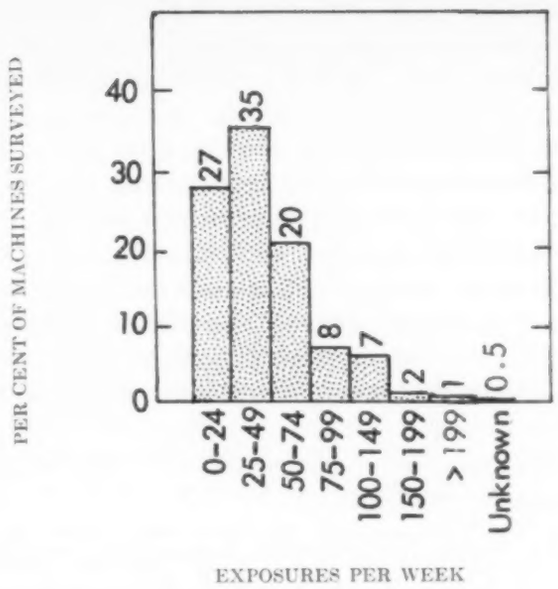


FIGURE 4.—DISTRIBUTION OF EXPOSURES PER WEEK

be noted, since 5 percent of the dentists had more than one X-ray machine.

Milliampere-Seconds Per Week: The total milliampere-seconds per week were obtained by multiplying the films per week by the product of the calculated average exposure time per film and the usual milliamperes used (see figure 5). Of all machines, 36 percent had less than 200 mas/wk., 53 percent had less than 300 mas/wk., 80 percent had less than 700 mas/wk., and 97 percent had less than 2000 mas/wk. The highest workload was 3180 mas/wk.

Maximum Exposure Rate of Personnel: The average maximum exposure rate for operators standing in the positions they normally used prior to the survey was 260 milliroentgens per hour, whereas the average maximum rate when standing in the new positions recommended as a result of the survey was 5.7 milliroentgens per hour, a reduction of 98 percent. For assistants, the corresponding values were 145 milliroentgens per hour and 5.2 milliroentgens per hour, a reduction of 97 percent. The readings taken at the positions normally used prior to the survey were made after recommended modifications to the machines had been completed; therefore, these readings are probably lower than the actual exposures of operators prior to the survey.

Protective Lead Shields: Only 15 percent of the installations had lead shields of one type or another; 7 percent had fixed shields with no window, 4 percent had mobile shields with leaded window, and 2 percent had fixed shields with leaded window. Only 16 percent had lead aprons, and 14 percent had lead aprons for the patient only, while 1 percent had aprons for both the operator and patient. Many of these with aprons used them only on pregnant women for full mouth X-ray series, or when requested. The use of leaded aprons during every X-ray exposure of each patient in or below the reproductive age was strongly recommended.

Skin Exposure per Film: The calculated average time per film was multiplied by the roentgen output per second to determine the average skin exposure per film. This was done using roentgen outputs both before and after filtration modification. The after-modification figures may be in error. If the dentist had 1.5 mm. filtration added and had good exposure and developing techniques before the survey, he might have had to increase his exposure time to get a clear film. This then would place the after-modification skin exposure per film used here in the report lower than the true figure. However, in most cases the exposing

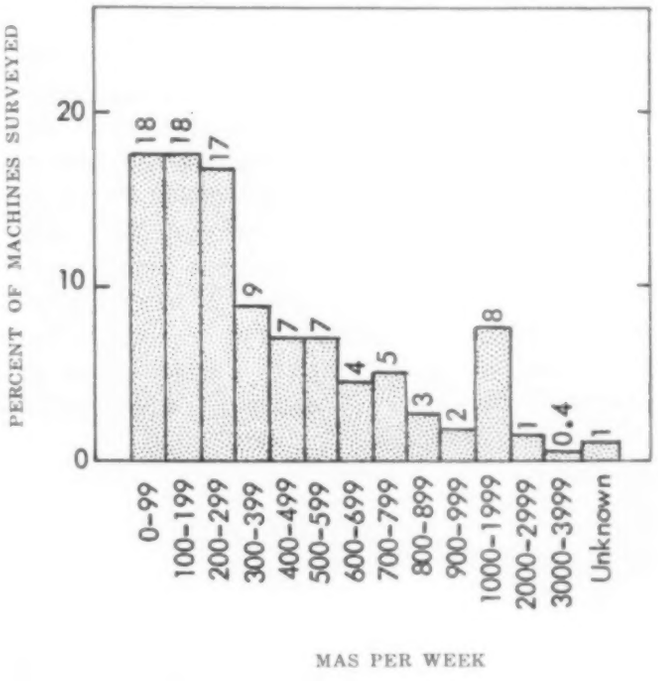


FIGURE 5.—MILLIAMPERE-SECONDS PER WEEK DISTRIBUTION

and developing techniques were not good—the exposure time was longer than necessary and the developing time was too short. Therefore, if the dentist used proper techniques after the survey (including faster film in some cases), the skin exposure per film used here could be greater than the true figure. Since these two possible effects tend to counterbalance each other, the latter effect being more probable, the figures used here should be approximately correct and probably somewhat conservative.

The reduction of the skin exposure per film may be seen in the following table. The reduction of the average exposure is 35 percent. One case was observed with a low value of 0.03 r/film. However, it is believed that a mistake may have been made in the recording of this value on the survey form. Therefore this figure is not shown on the following table.

TABLE 4.—SKIN EXPOSURE PER FILM

[Roentgens]

	Before modification	After modification
Maximum	8.99	4.05
Minimum	0.09	0.09
Average	1.32	0.88

The percentage less than 1.0 r/film was 55 before modification and 66 after modification.

Conclusions

It is felt that the physical survey was very worthwhile from the standpoint of the reduction of unnecessary radiation exposure. The earlier Surpak survey informed the dentists of some deficiencies in their machines and brought their attention to radiation exposure in general, resulting in some corrections being made. The physical survey covered a much larger portion of the diagnostic X-ray procedures and thus was able to accomplish more toward reducing unnecessary exposure. The correction of filtration and collimation during the survey helped a great deal, but large reductions of personnel and patient exposure were also brought about by procedural changes and the alteration of operating positions. It is emphasized that the reduction in potential exposures will be achieved only to the degree that the recommendations are followed. However, the response of dentists and assistants, in the vast majority of cases, strongly indicated an appreciation of the problems indicated and an equally strong tendency to follow recommendations.

Acknowledgements

The cooperation of the Industrial Commission of Utah, all local health departments in the State, the Utah State Medical Association, the Utah State Dental Association and the Utah State Radiological Society are gratefully acknowledged.

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STRONTIUM-90 IN HUMAN VERTEBRAE, 1962-1963 [1]

Joseph Rivera [2]

Since March of 1961, samples of human vertebrae have been obtained by the Health and Safety Laboratory (HASL) for strontium–90 analyses. The specimens are from accident victims who lived in New York City, Chicago, and San Francisco prior to death. Results of the analyses of specimens obtained during 1963 are presented in table 1 and for comparative purposes results obtained from the analyses of 1962 samples are presented in table 2. The results of the analyses of samples from San Juan will be reported in the near future. In each case it has been assumed that the calcium content of vertebrae was 0.37 g Ca/g ash, since this was the average result found from the analyses of over 115 samples (standard deviation ± 0.02 g/g ash).

On the average, the Sr^{90} content of vertebrae at each age was highest in New York City and lowest in San Francisco. This result is the same as that found for samples collected during 1961 and 1962, and is to be expected from the estimated dietary intakes of Sr^{90} at the three cities since 1960.

As in the previous years, the variation of Sr^{90}/Ca ratios with age was similar to that found by Kulp *et al.* (*1*) and other investigators. Highest strontium–90 concentrations were found in the bones of children under 1 year of age at death and lowest concentrations were found in the bones of individuals more than 20 years of age. There was also an indication of increased bone Sr^{90} concentrations during adolescence.

As compared with 1962, the 1963 average Sr^{90} concentrations of human vertebrae were higher for both children and adults. This result was also expected, since average dietary Sr^{90} levels during 1963 were higher than 1962.

Since the Sr^{90} content of the diet was increasing rapidly during the year, data on the Sr^{90} content of bone were tabulated as average values for each age, during both halves of 1963. The observed bone Sr^{90} concentrations were, on the average, higher for each age during the second half of the year than the first. The differences were particularly great for the youngest individuals, whose rate of bone formation was presumably higher than that of older people.

The Sr^{90} content of adult vertebrae containing one gram of calcium can be given by the following expression (*2*):

where: $X_n = X_{n-1} - f X_{n-1} + f K Z$,

X_n is the concentration of Sr^{90} for year 'n',

X_{n-1} is the concentration of Sr^{90} for year 'n—1',

f is the fraction of the bone Sr^{90} exchanged during the year,

K is the diet-bone observed ratio,

and Z is the Sr^{90}/Ca in the diet during the year.

In this equation all of the variables are known except 'f'. The HASL Tri-City diet studies yield estimates of Z for the three cities; X_n and X_{n-1} are given in tables 1 and 2 (>20 year old); and K has been established by numerous studies to be about 0.25 (*3*). Solving for 'f' and inserting the appropriate values for the other variables leaves:

$$f = \frac{X_n - X_{n-1}}{KZ - X_{n-1}}$$

$$f = \frac{1.55 - 0.90}{(.25)\,(30) - 0.90} = \frac{0.65}{6.60} = 0.10 \qquad \text{(New York City)}$$

$$f = \frac{1.11 - 0.79}{(.25)\,(19) - 0.79} = \frac{0.32}{3.96} = 0.08 \qquad \text{(Chicago)}$$

$$f = \frac{0.94 - 0.66}{(.25)\,(14) - 0.66} = \frac{0.28}{2.84} = 0.10 \qquad \text{(San Francisco)}$$

These results are in excellent agreement with the previously estimated value of 9 percent annual turnover for strontium in adult human vertebrae (*4*).

[1] Summarized from the Atomic Energy Commission's *Fallout Program Quarterly Summary Report, HASL–146:* 236–40, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (July 1964) price $3.50.

[2] Mr. Rivera is a physicist on the staff of Environmental Studies Division of the Health and Safety Laboratory, U. S. Atomic Energy Commission, New York, N. Y. 10014.

TABLE 1.—STRONTIUM-90 IN HUMAN VERTEBRAE, 1963

[Concentrations in pc/g Ca]

Age at death	New York City			Chicago			San Francisco		
	First half [a]	Second half [b]	All 1963	First half [a]	Second half [b]	All 1963	First half [a]	Second half [b]	All 1963
0–1	—	6.81 [c] (10)	6.81 (10)	—	3.51 (2)	3.51 (2)	1.31 (11)	2.43 (21)	2.04 (32)
1–2	3.49 [c] (1)	9.84 (1)	6.66 (2)	—	—	—	2.72 (2)	—	2.72 (2)
2–3	2.44 (3)	5.03 (3)	3.73 (6)	—	3.70 (2)	3.70 (2)	1.40 (6)	3.51 (1)	1.70 (7)
3–4	1.54 (1)	3.41 (2)	2.79 (3)	—	2.76 (3)	2.76 (3)	1.13 (5)	—	1.13 (5)
4–5	2.22 (1)	—	2.22 (1)	—	—	—	1.64 (2)	1.72 (3)	1.69 (5)
5–6	1.87 (2)	3.46 (1)	2.40 (3)	—	2.10 (1)	2.10 (1)	—	2.37 (3)	2.37 (3)
6–7	1.83 (2)	2.11 (1)	1.92 (3)	—	—	—	1.24 (1)	—	1.24 (1)
7–8	—	—	—	—	—	—	1.00 (1)	1.63 (3)	1.47 (4)
8–9	1.89 (4)	—	1.89 (4)	—	—	—	0.82 (2)	—	0.82 (2)
9–10	—	1.62 (1)	1.62 (1)	—	—	—	—	2.05 (1)	2.05 (1)
10–12	1.35 (1)	2.84 (1)	2.10 (2)	—	—	—	0.89 (1)	1.91 (2)	1.57 (3)
12–14	—	2.59 (1)	2.59 (1)	—	2.73 (1)	2.73 (1)	1.00 (1)	1.31 (4)	1.25 (5)
14–16	1.22 (1)	2.92 (1)	2.07 (2)	—	—	—	1.17 (1)	—	1.17 (1)
16–18	2.00 (4)	2.23 (2)	1.70 (6)	—	—	—	1.20 (3)	1.43 (2)	1.29 (5)
18–20	1.82 (2)	2.04 (2)	1.93 (4)	1.32 (1)	—	1.32 (1)	0.92 (1)	0.32 (1)	0.62 (2)
20–40	2.16 (1)	1.51 (11)	1.56 (12)	0.74 (2)	1.01 (4)	0.92 (6)	0.73 (3)	1.00 (11)	0.94 (14)
40–60	0.95 (1)	1.58 (5)	1.48 (6)	—	1.24 (4)	1.24 (4)	0.66 (2)	0.97 (4)	0.87 (6)
>60	—	1.61 (5)	1.61 (5)	—	1.43 (2)	1.43 (2)	—	1.21 (2)	1.21 (2)
0–4	2.47 (5)	6.24 (16)	5.34 (21)	—	3.24 (7)	3.24 (7)	1.41 (24)	2.48 (22)	1.92 (46)
4–20	1.85 (17)	2.41 (10)	1.97 (27)	1.32 (1)	2.41 (2)	2.05 (3)	1.13 (13)	1.66 (19)	1.44 (32)
>20	1.55 (2)	1.55 (21)	1.55 (23)	0.74 (2)	1.19 (10)	1.11 (12)	0.70 (5)	1.02 (17)	0.94 (22)

[a] Deceased January 1, 1963-June 30, 1963.
[b] Deceased July 1, 1963-December 31, 1963.
[c] Values in parentheses indicate number of samples.

A principle objective of the HASL bone sampling program is to see how well bone Sr^{90} concentrations can be predicted from diet Sr^{90} estimates. The data presented in this report indicate that:

1. The absolute levels of Sr^{90} in bone specimens collected in New York City, Chicago and San Francisco are proportional to the dietary Sr^{90}/Ca ratios estimated from the HASL Tri-City diet studies.

2. The variation of Sr^{90} levels in bone with time parallels the variations in Sr^{90} intake with time as estimated from the HASL Tri-City Diet studies.

3. Calculations of strontium turnover rates in human adult vertebrae, using observed bone levels and estimated dietary intakes, are consistent among the three cities.

TABLE 2.—STRONTIUM-90 IN HUMAN VERTEBRAE, 1962

[Concentrations in pc/g Ca]

Age at death	New York City			Chicago			San Francisco		
	First half [a]	Second half [b]	All 1962	First half [a]	Second half [b]	All 1962	First half [a]	Second half [b]	All 1962
0–1	4.03 [c] (3)	3.58 (11)	3.68 (14)	1.40 (1)	—	1.40 (1)	1.24 (5)	0.99 (16)	1.05 (21)
1–2	2.83 (3)	4.24 (2)	3.39 (5)	—	2.32 (1)	2.32 (1)	1.00 (2)	0.90 (2)	0.95 (4)
2–3	2.11 (1)	2.87 (4)	2.72 (5)	—	—	—	0.77 (2)	1.54 (4)	1.28 (6)
3–4	2.28 (3)	2.78 (6)	2.61 (9)	0.68 (1)	—	0.68 (1)	1.18 (2)	1.49 (1)	1.22 (3)
4–5	2.03 (3)	—	2.03 (3)	0.96 (2)	—	0.96 (2)	1.92 (2)	0.76 (1)	1.53 (3)
5–6	—	—	—	1.89 (1)	1.46 (1)	1.68 (2)	0.65 (2)	0.57 (1)	0.62 (3)
6–7	1.54 (2)	2.86 (1)	1.98 (3)	1.49 (1)	—	1.49 (1)	1.25 (1)	1.03 (2)	1.10 (3)
7–8	1.83 (2)	1.65 (1)	1.77 (3)	—	—	—	0.97 (2)	—	0.97 (2)
8–9	—	1.67 (5)	1.67 (5)	—	—	—	—	—	—
9–10	0.89 (1)	1.46 (1)	1.18 (2)	1.43 (1)	—	1.43 (1)	—	0.51 (1)	0.51 (1)
10–12	1.55 (1)	—	1.55 (1)	1.10 (3)	—	1.10 (3)	0.53 (2)	—	0.53 (2)
12–14	1.13 (2)	1.93 (3)	1.61 (5)	0.73 (1)	1.43 (1)	1.08 (2)	1.20 (1)	—	1.20 (1)
14–16	1.32 (6)	—	1.32 (6)	1.27 (1)	1.78 (1)	1.53 (2)	1.28 (2)	0.97 (1)	1.18 (3)
16–18	1.34 (2)	1.98 (3)	1.72 (5)	—	1.51 (1)	1.51 (1)	—	1.10 (1)	1.10 (1)
18–20	1.31 (2)	2.05 (2)	1.68 (4)	0.76 (1)	—	0.76 (1)	—	0.97 (4)	0.97 (4)
20–40	0.66 (3)	1.32 (2)	0.92 (5)	0.54 (11)	1.22 (7)	0.80 (18)	0.96 (2)	0.92 (3)	0.94 (5)
40–60	0.50 (2)	0.91 (2)	0.70 (4)	0.63 (29)	0.90 (6)	0.68 (35)	—	0.54 (4)	0.54 (4)
>60	1.02 (3)	1.08 (2)	1.04 (5)	1.47 (5)	0.94 (1)	1.38 (6)	—	0.59 (11)	0.59 (11)
0–4	2.95 (10)	3.31 (23)	3.20 (33)	1.04 (2)	2.32 (1)	1.47 (3)	1.10 (11)	1.10 (23)	1.10 (33)
4–20	1.46 (21)	1.88 (16)	1.64 (37)	1.16 (11)	1.55 (4)	1.26 (15)	1.10 (12)	0.90 (11)	1.00 (23)
>20	0.76 (8)	1.10 (6)	0.90 (14)	0.70 (45)	1.06 (14)	0.79 (59)	0.96 (2)	0.63 (18)	0.66 (20)

[a] Deceased January 1, 1962-June 30, 1962.
[b] Deceased July 1, 1962-December 31, 1962.
[c] Values in parentheses indicate number of samples.

The conclusions therefore reached are that the HASL Tri-City estimates do represent fairly accurately the actual average Sr^{90} intake at the respective cities, and that the Sr^{90} content of adult vertebrae can be calculated using these diet estimates, a turnover rate of 9 percent per year and a diet-bone observed ratio of 0.25.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for Lawrence Radiation Laboratory sites and the Los Alamos Scientific Laboratory.

1. Lawrence Radiation Laboratory Calendar Year 1963

University of California
Berkeley, California

Berkeley Site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the campus of the University of California (see figure 1). Technical facilities include a 6.3 Bev proton accelerator (Bevatron), a 700 Mev cyclotron, a linear accelerator of 10 Mev per nucleon, 88-inch cyclotron, and various chemistry and physics laboratories.

The environmental sampling program includes monitoring of the atmosphere, water and rain or dry deposition. Three types of atmospheric samples are taken: stack samples, local area samples, and perimeter samples. Data for these are shown in table 1.

TABLE 1.—ATMOSPHERIC MONITORING, BERKELEY SITE 1963

[Average concentrations in pc/m³]

Sampling location	Total No. of samples	First half		Second half	
		Alpha	Beta	Alpha	Beta
Stacks	5,460	0.006	3.10	0.005	2.90
Local area	510	0.001	8.50	0.001	2.79
Perimeter	206	0.001	9.58	0.001	3.14

Approximately 75 "stacks", mostly laboratory hoods and glove box exhausts, are being sampled. These represent the greatest potential for releasing activity. One-inch-diameter filters are used at flow rate of one liter per minute. The filters are changed weekly and counted for beta activity by an end-window Geiger-Mueller tube and for alpha activity by a zinc sulfide scintillation detector. Limits of detection for an individual stack sample were 0.10 pc/m³ alpha and 2.3 pc/m³ beta. Local area and perimeter air samples are taken on outdoor areas on the Laboratory site and at the property line, respectively. The samples are taken on 4" x 9" HV–70 filter paper at 4 cfm. The filters are changed weekly and are counted for alpha activity by a large area gas flow proportional counter and for beta activity by two Geiger-Mueller tubes, with 30 mg/cm² window. A 40 percent loss in the alpha count is assumed for self absorption. Limits of detection were 0.15 pc/m³ beta and 0.005 pc/m³ alpha.

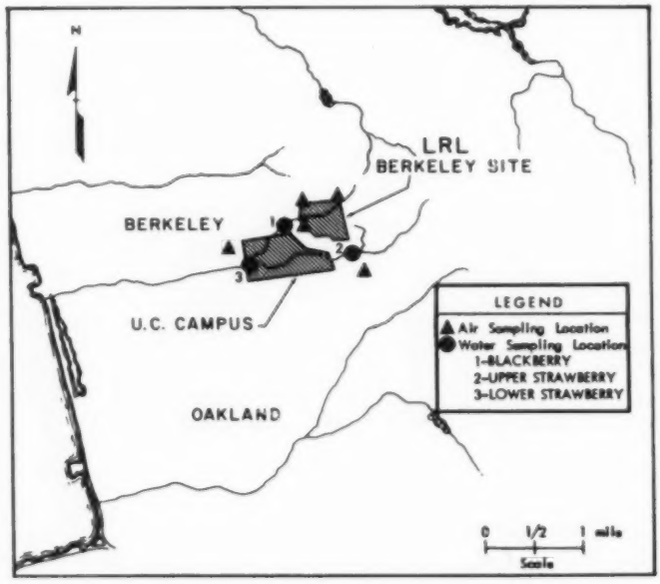

FIGURE 1.—ENVIRONMENTAL SAMPLING LOCATIONS AT THE BERKELEY SITE

Rain or deposition samples are collected in 18-inch-diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Deposition data are given in table 2. At two remote locations in Berkeley and Oakland, samples are collected in small rain gauges. The bag is changed monthly at all stations. Rain samples are poured out and evaporated in beakers. If the bag is dry, it is rinsed out with dilute nitric acid which is then evaporated. Final evaporation is in 2″ diameter stainless steel planchets which are then flamed and coated with a thin film of lacquer. These planchets are counted for alpha activity in an internal flow proportional counter and for beta activity with a thin window low background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Detection limits vary, depending on the size of the sample and length of time counted.

TABLE 2.—TOTAL DEPOSITION, BERKELEY SITE, LAST HALF 1963

[Average concentrations in nc/m²]

Location	Number of samples	Alpha	Beta
Local area	57	0.09	40.54
Perimeter	24	0.15	60.23

Water samples are taken from laboratory wastes, onsite streams and offsite streams. The laboratory waste is sampled at two buildings designated by numbers 70 and 71. At building 70, a continuous sample is collected from the acid waste system for weekly analyses. This represents about one-fourth of the total Laboratory discharge to the sewer. Samples of approximately two liters each are acidified, evaporated and counted in the same manner as rain samples. Detection limits vary but were no greater than 0.4 pc/liter alpha and 1 pc/liter beta.

Waste from laboratory areas in building 71 is retained in 350-gallon holding tanks until analyzed. A one-quart sample is taken from each tank and is handled and counted in the same manner as samples taken at Building 70.

Surface water on the Laboratory site drains into two small streams which merge into one at the lower end of the University campus. One side stream (Upper Strawberry) and the final combined stream (Lower Strawberry) are sampled biweekly; the other side stream (Blackberry) is sampled weekly. Six nearby offsite creeks are also sampled. The four nearest ones are sampled bi-weekly, the other two more remote ones every four weeks. One-quart samples are taken in each case and handled in the same way as rain samples. The sampling stations are shown in figure 1. Results for all water samples are shown in table 3.

TABLE 3.—WATER MONITORING, BERKELEY SITE, 1963

[Average concentrations in pc/liter]

Type of sample	Total No. of samples	First half		Second half	
		Alpha	Beta	Alpha	Beta
Sewage	123	0.20	22.2	0.28	132
Tap water	53	0.05	21.4	0.14	16.6
Onsite streams	156	0.64	44.9	2.05	20.8
Offsite streams	104	0.32	13.3	0.80	4.7

Livermore Site

The Livermore site of LRL is located three miles east of Livermore, California (see figure 2). Technical facilities include a small cyclotron, a two-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent and sewage plant products. Air samples were collected to ascertain that control efforts are restricting the release of radioactivity from the Laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples were collected to monitor radioactivity in an underground water supply which is the sole source of domestic water for the cities of Livermore and Pleasanton.

Air samples are collected continuously at 11 sites within 5 miles of the LRL. The 4″ x 9″ HV–70 sampling papers are changed after seven days of sampling at a rate of 4 cfm. A minimum decay period of 96 hours was observed before the papers were counted to eliminate the effect of natural radon and thoron daughters. The alpha activity remaining was

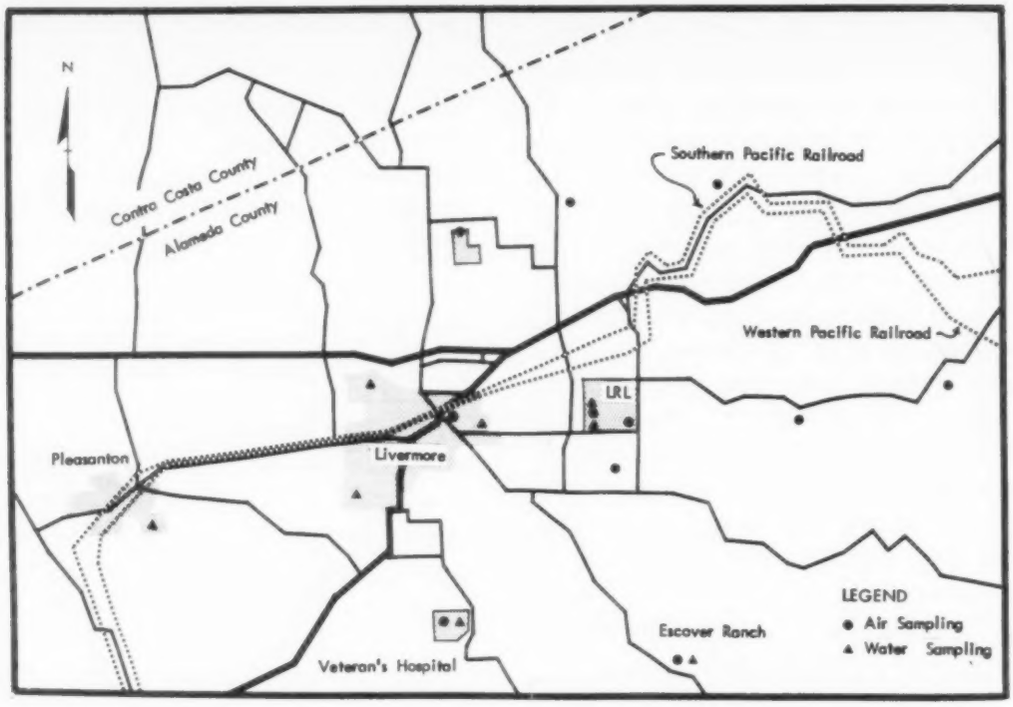

FIGURE 2.—SAMPLING LOCATIONS AT THE LIVERMORE SITE

measured with a counter equipped with a zinc sulfide scintillation detector with a counting efficiency of about 30 percent. The beta activity was measured with a Geiger-Mueller tube with a counting efficiency of about 13 percent. The standards of comparison used were 0.04 pc/m^3 for alpha and 10 pc/m^3 for beta as recommended in NBS handbook No. 69. The limit of sensitivity was 0.00073 pc/m^3 for alpha and 0.0059 pc/m^3 for beta. Average results for the eleven air sampling stations, which collected 800 samples at Livermore in 1963 were 0.0025 pc/m^3 alpha and 2.33 pc/m^3 beta. The alpha average concentration was about half of that of 1962 and the beta was 2.33 pc/m^3 for 1963 compared to 2.1 for 1962.

Domestic water samples were collected monthly from two onsite wells and six nearby areas to insure that radioactivity from Laboratory operations is not entering the underground water supply which provides most of the drinking water for Livermore and Pleasanton, and all of the water for ranches in the valley. The average radionuclide concentration in all of the domestic water samples was below the limit of sensitivity for alpha (8.9 pc/liter) and for beta (41 pc/liter). The standards of comparison used were 10 pc/liter for alpha and 600 pc/liter beta as recommended in NBS handbok 69. The gas proportional counter used in these measurements had a counting efficiency of 36 percent for alpha and 31 percent for beta emitters.

Samples of top layer soil were collected quarterly at the 19 sampling stations surrounding the Livermore Site. The alpha activity was below the limit of sensitivity—50 pc/g—for all the samples. The beta activity averaged 44 pc/g. This concentration was less than the 1962 average of 100 pc/g.

Continuous sampling is maintained at the sewer line leaving the southwest project boundary where it connects with the Livermore domestic sewer lines. As a back up to the sewer effluent sampling program, grab samples were collected monthly at the Livermore Sewage Disposal Plant to establish that liquid effluent from the laboratory is not creating abnormal radioactivity concentrations in the oxidation ponds and dried sludge. The sludge is used as an agricultural soil conditioner and the oxidation ponds overflow into a natural waterway. The results for effluent monitoring at Livermore 1963 are summarized in table 4.

TABLE 4.—EFFLUENT MONITORING, LIVERMORE SITE, 1963

[Average concentrations in pc/liter]

Type of sample	Number of samples	First half		Second half	
		Alpha	Beta	Alpha	Beta
Sewer effluent	130	6.1	130	6.3	130
Oxidation pond	15	9.2	145		
Sewage plant (pc/gm)	39	6.7	46		

Note: Standard of comparison (alpha + beta) 300.

A program for the measurement of low level "background" radiation was initiated in February 1963. Standard personnel film was used for the first five months, then fluoroglass dosimeters were used after June to integrate the external "background" radiation. Thirteen dosimeters were placed at strategic locations on the security fence approximately four feet above ground and three dosimeters were placed at offsite ranches. The dosimeters were left in the field for six months. The external radiation dose was less than 50 mr for 1963, the limit of detectability, at the Laboratory perimeter and at the offsite locations. Therefore, the external radiation dose rate at the Laboratory perimeter was approximately 0.01 mr/hr, essentially natural background.

Site 300

Site 300 is part of the LRL operation at Livermore. The site is located in a very sparsely populated ranching area about 17 miles southeast of LRL at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal concentrations in the vicinity. Lack of power facilities necessitated installation of most of the air samplers within the boundaries of the site. All the water samples were taken from wells located on the site because they are the only readily accessible source of underground water in the area. All samples, air and water, are processed at LRL, Livermore.

Air sampling was on a continuous basis at seven stations, and the filter papers were changed three times per week. The standards of comparison for alpha are 1 pc/m^3 for the onsite stations and 0.1 pc/m^3 for the offsite station located at Tracy, eight miles northeast of Site 300. The standards for beta are 1,000 pc/m^3 onsite and 100 pc/m^3 offsite. Average results for all air station samples combined are shown in table 5.

Soil and water samples were collected once per month at both on and offsite locations. Only top layer soil was collected to determine fallout concentrations. Onsite wells, the only domestic water sources for the site, were sampled monthly whereas offsite streams were sampled only during the winter months when water flow existed. The average soil and water concentrations for the past year are summarized in table 5. The standards of comparison for alpha are 6,000 pc/liter for onsite locations and 600 pc/liter for offsite locations. For beta emitters, the standards are 30,000 pc/liter for onsite locations and 3,000 pc/liter for offsite locations.

Previous coverage in *Radiological Health Data:*

Period	Issue
Fourth Quarter 1960 and First Half 1961	*March 1962*
Second Half 1961	*October 1962*
Calendar Year 1962	*October 1963*

TABLE 5.—ENVIRONMENTAL SAMPLING, SITE 300, 1963

[Average concentrations in pc/m^3]

Type of sample	Number of stations	First half			Second half		
		Number of samples	Alpha	Beta	Number of samples	Alpha	Beta
Air (pc/m^3)	7	858	0.0028	3.0	430	0023	2.0
Soil (pc/g)	9	90	<5	45		5	40
Onsite wells (pc/liter)	6	69	<8.9	<41			
Offsite streams	3	11	<8.9	<41			

2. Los Alamos Scientific Laboratory, 1962-1963

University of California
Los Alamos, New Mexico

As part of the environmental monitoring program at Los Alamos, measurements of air particulate radioactivity, activity in precipitation and gamma background are made periodically. The samples were taken on the roof of building TA–50 (about 1¾ mile S.E. of the Administrative Building, the former location) starting in March 1963. Gamma background surveys were discontinued in March 1963.

Air Monitoring

Airborne radioactive particulate matter is collected on 4-inch-diameter filters. The sampling rate was reduced from 46 m^3/hr in 1962 to 25.5 m^3/hr in 1963, due to the addition of an activated charcoal filter behind the first filter. Air samples are ordinarily collected for 24 hour intervals during the work week; 72-hour weekend samples are collected.

The filters are counted for beta activity 7 days after collection in a thin-window (methane) flow proportional counter, with an over-all efficiency for Sr^{90}–Y^{90} of 50 percent. Results are tabulated in table 6 and show a decrease in beta activity in 1963 over that of 1962. The MPC value for beta in air is 100 pc/m^3 as stated in NBS Handbook No. 69.

TABLE 6.—BETA ACTIVITY OF PARTICULATE MATTER IN AIR, 1962–1963

[Concentrations in pc/m^3]

Year	Average/sample	Maximum	Minimum
1962	4.47	31.05	0.37
1963	4.16	38.22	0.22

Precipitation Monitoring

Collection is made in a 0.4 square meter rain collector which delivers 1 liter of water for each 0.1 inch of precipitation. Even during relatively dry periods it has been found that this arrangement collected activity. By washing down the sides of the collector with 1 liter of distilled water, a suitable sample is obtained. These "wash" samples, as well as any precipitation, are reduced in volume, dry-plated on 1 inch stainless steel planchets, and counted in an automatic beta counting system, installed in late 1963. This system has a gas flow proportional counter, which provides increased efficiencies and lower background. (Counting was previously done in an end-window Geiger-Mueller counter with a window thickness of 1.9 mg/cm^2.

The present results are comparable with past results in that the same standard is used for determining geometry and efficiency. The counting efficiency is determined by comparison with a radium D + E standard which emits 1.17 Mev beta particles. Results are tabulated in table 7. Average "per day" values for the rain gauge collection are the total activity collected during the month divided by the number of days.

TABLE 7.—BETA ACTIVITY IN PRECIPITATION, 1962–1963

Year	Precipitation (mm.)	Deposition in pc/m^2 average/day
1962	393.19	1318
1963	452.88	1739

Previous coverage in *RHD*

Period	Issue
1960–1961	*October 1962*

REPORTED NUCLEAR DETONATIONS, SEPTEMBER 1964

During September 1964 the AEC announced one underground nuclear test of low yield conducted on the fourth at the Nevada Test Site. (RHD reference number 166. Low yield is defined as equivalent to less than 20 kilotons of TNT.)

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UNITS AND EQUIVALENTS

Symbol	Unit	Equivalent
Bev	billion electron volt	
cpm	count per minute	
dpm	disintegration per minute	
g	gram	
kg	kilogram	1 kg = 1000 gm = 2.2 pounds
km^2	square kilometer	
kvp	kilovolt peak	
m^3	cubic meter	1 m^3 = 1000 liters
ma	milliampere	
mas	milliampere-second	
Mev	million electron volts	
mi^2	square mile	
ml	milliliter	
mm	millimeter	
mrad	millirad	
mrem	millirem	
mr/hr	milliroentgen per hour	
mμc	millimicrocurie	1 mμc = 1 nc
nc	nanocurie	1 nc = 1000 pc = 1 mμc $=10^{-9}$ curies
nc/m^2	nanocurie per square meter	1 nc/m^3 = 1 $m\mu c/m^3$ = 1,000 $\mu\mu c/m^3$ = 1 mc/km^3 = 2.59 mc/mi^3
pc	picocurie	1 pc = 1 μμc = 10^{-12} curies
r	roentgen	
μμc	micromicrocurie	1 μμc = 2.22 dpm

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	jĭ' ga	
10^{6}	mega	mĕg' a	
10^{3}	kilo	kĭl' o	
10^{2}	hecto	hĕk' to	
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

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